

E L E M E N T S  
O F  
N A T U R A L H I S T O R Y,  
A N D O F  
C H E M I S T R Y:

BEING THE SECOND EDITION OF  
THE ELEMENTARY LECTURES ON  
THOSE SCIENCES,

FIRST PUBLISHED IN 1782,

A N D N O W

GREATLY ENLARGED AND IMPROVED,

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TRANSLATED INTO ENGLISH.

WITH OCCASIONAL NOTES, AND AN HISTORICAL  
PREFACE, BY THE TRANSLATOR.

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VOL. IV.

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E L C M E N T S

NATURAL HISTORY

CHEMISTRY

THE ELEMENTARY LESSONS

IN THE SCIENCE



OF THE MUSEUM OF BRITAIN

AND THE MUSEUM OF NATURAL HISTORY

OF THE MUSEUM OF BRITAIN

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# C O N T E N T S

TO VOL. IV.

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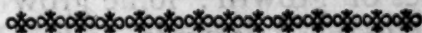
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ELEMENTS

E L E M E N T S  
OF  
N A T U R A L H I S T O R Y,  
AND OF  
C H E M I S T R Y.



P A R T III.

The Vegetable Kingdom.

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C H A P. I.

Concerning the Structure of Vegetables.

**V**EGETABLES are organized bodies, fixed at the surface of the earth, and possessing neither sensibility nor spontaneous motion. They are distinguished by their external appearance and construction, and differ more particularly from minerals, in the circumstance

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stance of their being nourished by intossuption, and their elaborating the juices designed to increase their bulk. They present phenomena, which depend on their organization, and are called functions; the principal of which is, their reproduction, by means of seed, or eggs, like animals.

Vegetables differ from each other, 1. By their magnitude: they are distinguished into trees, shrubs, herbs, mosses, &c. 2. By their places of growth: some grow in dry, and others in moist grounds; others in sand, clay, water, on the surface of stones, or on other vegetables, &c. 3. By their smell, taste, colour, &c. 4. By their duration: plants are perennial, annual, biennial, &c. 5. By their use, either as food, medicine, &c. A great number are used in the arts, such as dying, &c. others are used merely for pleasure, ornament, &c.

Vegetables, externally considered, are formed of six parts, or organs, destined to perform peculiar functions. These parts are the root, the stem, the leaf, the flower, the fruit, and the seed. These differ in form, texture, magnitude, number, colour, duration, taste, &c.

1. The root is concealed in the earth, in water, or in the bark of other vegetables. It is either tuberous, or fibrous, or bulbous. Its direction is either perpendicular, or horizontal; and its consistence, as well as its form,

form, is subject to great variations. Botanists distinguish them into several species, and avail themselves of these distinctions, as specific characters.

2. The stem grows out of the root, and sustains the other parts. It is either solid, or hollow, ligneous or herbaceous, round, square, triangular, or having two acute angles, &c. The stem comprehends the wood and the bark. The wood is distinguished into wood, properly so called, and sap. The bark consists of the epidermis, the pulp or vesicular part, and the cortical strata, or inner rind. The stem is divided into branches, which have absolutely the same structure; and the diversity of this part very often serves to establish the distinctive characters of the species and varieties.

3. The leaves of vegetables are exceedingly varied. A By their form: they are oval, round, sagittate, hastate, oblong, elliptic, cuneiform, &c. B By their position on their stem: they are either sessile, petiolate, opposite, alternate, stellate, perfoliate, vaginant, &c. C By their margin: they are either uniform, dentate, crenate, serrate, repand, undulated, lacerated, truncated, &c. D By their simplicity or composition: compound leaves are formed, by the insertion of foliolæ, or lesser leaves, and are then either digitate or conjugate, with either an odd or an even number of



leaves. E By their position or place: they are radical, cauline, or floral. F By their colour, smell, taste, consistence, &c. Their use appears to consist in absorbing the elastic fluids of the atmosphere, and exhaling different kinds of air, according to circumstances.

4. The flowers are parts designed to contain the organs of generation, and defend them till the fecundation is accomplished, at which time they fall. The flower is distinguished into two parts: the external part serves to inclose and protect the internal part, whose use consists in reproducing the plant. The former comprehends the calyx, and the corolla. The calyx is external, and green. Linnæus distinguishes it into seven species; namely, the perianthium; the spatha, or sheath; the husk; the involucre; the amentum, or catkin; the calyptra, or veil; and the volva. The corolla is the coloured part commonly called the flower; it is either monopetalous, or consisting of one single piece; or polypetalous, consisting of several parts. The system of Tournefort is founded on the corolla. The parts of the corolla are called petals. The organs included, and often concealed in plants, are the stamina, and the pistils or styles. The stamina are the male, or fecundating parts, and are almost always more numerous than the pistils. They consist of the filament,  
and

and the anthera. This last, placed at the extremity of the filament, is a small bag, containing the fecundating powder. The pistil is in the midst of the stamina: it is sometimes on another flower, or even on another plant; which circumstance occasions the distinction of plants into male and female. The pistil consists of three parts; the inferior part, which contains the embryo, and is called, in Latin, germen; the filament, which grows out of the inferior part, and is called the style; and its extremity, which is more or less dilated, is called stigma. The sexual system of Linnæus is founded on the number and position of the stamina and pistils. Mr. De Jussieu has established a system, founded on the insertion of the stamina above or below the germen, &c.

5. Flowers are succeeded by fruits. Botanists distinguish seven species; the capsule, the filiqua, the legumen, the conceptaculum, which becomes dry; fruits having kernels, fruits having pippins and berries, which remain succulent. These organs are designed to inclose the seeds, and defend them from external agents.

6. The seed differs greatly in its form, magnitude, appendices, &c. It contains the plumula, or small plant; the radícula, and the cotyledons. These last are two in number in most vegetables; but many families of plants have no more than one co-

yledon. This part is to the grain, what the yellow and white of the egg is to the embryo bird; it contains a proper nourishment for the individual during the germination.

Vegetables, considered with respect to their internal parts, present five species of vessels, or organs, which exist in all their parts; 1. The common vessels, which conduct the sap: they are placed in the central part of plants and trees, and rise perpendicularly, though with lateral bendings, so as to form small vacancies between them. 2. The proper vessels, which convey the juices peculiar to each vegetable, such as the oils, gums, resins, &c. They are placed beneath the bark, and appear in many places to be dilated into cavities, or reservoirs, which seem to be the excretory vessels. 3. The tracheæ, or vessels through which air circulates: when a young green branch is torn asunder, they may be observed of a spiral form, resembling a cork-screw. They are often filled with sap. 4. The utricles, or small vessels, which contain a secreted juice, and frequently colouring matter. They are placed in the middle of the stem. 5. The vesicular tissue, which exhibits a series of small cells, which leading horizontally from the pith, and crossing the sap vessels, and filling the vacuities between them, are expanded beneath the epidermis, form a kind of soft covering, resembling the skins of animals.

The

The vesicular tissue of vegetables appears to answer to the cellular membrane of animals.

All the parts of vegetables consist of an assemblage of these five kinds of vessels, each in particular being more or less numerous, dilated, contracted, &c. The differences in the form and texture of roots, stems, leaves, &c. depend on this diversity of number and disposition.

Malpighi, Grew, and Duhamel, have been the most successful in their researches into the natural history of plants, and their works are the most instructive, with respect to the internal formation of their several parts.

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## C H A P. II.

### The Natural Philosophy of Vegetables.

THE organs of vegetables, which we have concisely described in the foregoing chapter, are designed to perform several motions, which are called functions. These functions are,

1. The motion, or circulation of the fluids.
2. The alterations, or change of these fluids, by secretion.

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3. The



3. The augmentation and developement of the vegetable by nutrition.
4. The exhalation of different fluids elaborated in the organs of vegetables, and the inhaling of several principles contained in the atmosphere, by the same organs.
5. The action of the air, and the use of this fluid in the vessels of vegetables.
6. The motion performed by some of their parts.
7. The kind of sensibility by which they endeavour to obtain the contact of such bodies as tend to promote the functions, such as light, &c.
8. And lastly, The various phenomena which serve to reproduce the species, and constitute the generation of plants. We shall consider each of these functions separately.

The principal fluid of vegetables, which is known by the name of sap, is contained in peculiar vessels, called the common vessels. These vessels, which are placed in the middle of the stem, and beneath the bark, are extended from the root to the leaves and flowers. The sap which they conduct, is a colourless fluid, of an insipid taste, and, like the blood in animals, becomes separated into different juices, for the nourishment and support of the several organs. It is very abundant

dant in the spring, its presence being then shewn by the production of leaves and flowers. All the phenomena of vegetation, as well as experiments made by applying ligatures about plants, shew, that it rises from the root to the stem and branches. But it is not so well ascertained, that it descends again towards the root, as some philosophers have affirmed. The valves admitted to exist, by many botanists, in the common vessels, have not been exhibited; unless we may call by this name certain fibres, or hairs, with which their internal parts appeared to be lined, according to Tournefort and Duhamel. Their regular motion of this fluid is very far from resembling the circulation in animals.

The sap, when conveyed into the utricles, and thence into the proper vessels, is elaborated in a peculiar manner: it produces different saccharine, oily, mucilaginous fluids, which are emitted in consequence of an organic process, and whose evacuation seems to be an advantage to the vegetable, since it does not receive any damage from a very considerable occasional loss of those matters. This alteration of the fluids, which is very observable in many organs, as in the nectarium, at the extremity of the pistil, in the pulp of fruits, at the base of the calyces, and of many leaves, is produced intirely by that function, which in animals is called secretion.

tion. Guettard has carried this analogy so far, as to describe glands of various forms at the bases of the leaves of fruit trees, and towards the inner extremity of the petals of certain flowers. It is this secretion which develops the principle of smell, the colouring matter, the combustible substance, &c. But it differs very essentially from animal secretion, which is intirely produced by the organization of the glands, which elaborate the animal fluids; whereas, in vegetables, the juices contained in the common vessels are more exposed to the contact of air, light, and the action of heat; and their situation renders them capable of passing through the processes of fermentation by means of these agents.

The sap, while it remains in the cavities of the utricles, and of the vesicular tunic, becomes thick, and more consistent. This alteration renders it capable of adhering to the sides of the fibres, and of gradually augmenting their dimensions. Such is the mechanism of the nutrition of vegetables, their increase of magnitude, and the developement of their parts. It greatly resembles the nutrition of animals. The vesicular tunic, and the utricles, have the same conformation, and the same use in both classes of organized beings. In both, they penetrate all their organs, establishing an immediate communication

nication between them, and in both they are the true seat of nutrition.

Philosophical botanists have long been convinced, that exhalations are emitted into the air from the surfaces of plants. The odorous exhalation of leaves and flowers forms an atmosphere around vegetables, which strikes our senses, and which the contact of a body on fire is sometimes capable of inflaming, as has been observed with regard to the *fraxinella*. This exhalation appears to be a peculiar kind of inflammable gas. Experience has likewise shewn, that many vegetables emit vapours which are mortal to such animals as remain long exposed to them. Such are the yew, and many trees, natives of hot countries. The experiments of Mr. Ingenhoufz have shewn, that the leaves of all plants exposed to the light of the sun emit an invisible fluid, which consists of true vital air, similar to that which is obtained from calces of mercury, &c. This property of leaves is intirely changed in the shade, in which situation they emit the cretaceous acid. This happy discovery, first published by Dr. Priestley, shews an unsuspected property in plants, namely, that of purifying and renewing the air, by restoring that portion of vivifying fluid which is continually destroyed by combustion, respiration, &c. But at the same time that vegetables continually emit vaporous



rous fluids produced in the last processes of vegetation, they likewise absorb many of the principles contained in the atmosphere. The lower surface of leaves absorbs the humidity of the dew, according to the experiments of Bonnet. Dr. Priestley's experiments likewise prove, that vegetables absorb the gases, which remain after combustion and respiration, and that vegetation is stronger in air changed by these processes. The exhalation and inhalation at the surface of vegetables are consequently much more considerable than was supposed before the time of the modern discoveries. It even appears that the water absorbed by the inferior surface of leaves is decomposed; that the base of inflammable air it contains is absorbed; and that the pure air disengaged from the superior surface of the leaves is produced by the oxygenous principle contained in that fluid. The contact of the rays of the sun contributes greatly to this decomposition, as it does not take place in the shade. Plants defended from the action of light, absorb water intirely without decomposition, and become white, insipid, and soft; a much less quantity of coloured, combustible, or oily matter, being formed.

The gases absorbed by vegetables, are conveyed into all their organs by the air vessels, which in their use and structure resemble those of insects and worms. The air vessels

sels are not, however, appropriated solely to the circulation of elastic fluids; for they are observed to be filled with sap, at those times of the year in which that fluid is most abundant: a circumstance which constitutes a great difference between them and the organs of respiration, so essential to the existence of a great number of animals. From the theory of respiration, which we have explained in the history of air, it is easy to shew why the temperature of vegetables does not exceed that of the air which surrounds them.

It cannot be doubted, but that many parts of vegetables have an internal principle of motion; in some it is so evident, as to be most obviously distinguished. Such is the motion of the sensitive plant, of the stamina of the Indian fig, of pellitory, &c. This motion seems to depend on the function, which is known in animals by the name of irritability; for it is excited by the action of a stimulus, and has peculiar organs, which some botanists have compared to muscular fibres.

Ought we not to admit a sort of sensibility in plants, when we observe them to turn their leaves and flowers towards the sun, and when we observe that plants, inclosed in wooden boxes, glazed on one side, perforated, or merely thinner on one side than the others, constantly tend towards the trans-

transparent body, or the aperture through which the light passes, or even towards the side, which by its less thickness may admit a glimmering light? Or may we not attribute this apparent sensibility to the force of affinity, or tendency to combination, which exists between vegetables with light? It is well established, that this fluid, either by percussio or combination, assists in producing the colour, taste, and combustible property in plants; because plants, which grow in the shade, are white, insipid, aqueous, and contain no inflammable matter; whereas vegetables exposed, in the burning climates of the south, to the strong rays of the sun, become highly coloured, abound with bitter and resinous parts, and are eminently combustible. However strong we may suppose this affinity to be, we cannot conceive how it should be capable of exciting a motion so considerable in the branches and leaves of vegetables. We must therefore necessarily admit a peculiar kind of sensation, or feeling, very different, it is true, from the senses of animals, by means of which vegetables give a preference to such situations as are most accessible to light.

The manner in which the species are produced, among vegetables, greatly resembles the generation of animals. The existence and union of sexes are necessary in the greatest number of plants. The labours of the  
celebrated

celebrated Linnæus have discovered a strong analogy between the organs destined for this function in the two classes of organic beings. The stamina correspond with those of the male sex, and the pistil is composed of three parts, analagous to those of the genitals of female animals. The embryo is developed, by the action of the fecundating powder, without which it is not capable of producing an individual, as is likewise daily observed among birds. But besides this analogy, which need not be further pursued, vegetables are of a much simpler structure than animals; and all their parts being composed of the same organs, each is capable of producing a new individual similar to itself. This is the reason of the reproduction of plants, by means of scions or slips, as well as the alteration of the fluids, by grafting, whether natural or artificial. There is likewise another analogy, of modern discovery, between vegetables and that class of animals which is reproduced, by division into pieces, as the polypus, crustaceous insects, certain worms, &c.

All the functions, which, taken together, constitute the resemblance between vegetables and animals, are susceptible of alterations, which produce disorders. These depend, most commonly, on the abundance or defect of the sap, as well as its bad qualities, and are analogous to those which take place



place in animals. Their causes, symptoms, and cure, are alike referable to the general principles of medicine, and form a part of agriculture, which it must be confessed is not much advanced, but capable of great improvement, according to the plans of several celebrated authors.

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### C H A P. III.

#### Concerning Juices and Extracts.

**T**HE fluids contained in vegetables, are of two kinds; the common, and the proper juices. The first, consists of the sap which is found in all plants. It is contained in the common vessels, flows naturally out of their surface, but is more abundantly extracted by incision. The sap is not merely an aqueous fluid, but contains salts, extracts, and mucilages. When a certain quantity is desired, either for medical use, or philosophical inquiry, the plant is beat in a mortar, and pressed in a cloth, beneath a press, if necessary.

Succulent vegetables give out their juice by simple expression; but those whose juices are viscous, or in small quantity, require to be diluted with water, such as borage, and the

the dry aromatic plants. This fluid being extracted, by strong pressure, is found to contain a portion of the solids of the vegetables beaten small by the pestle, and consequently requires depuration; which may be effected either, A By subsidence, or filtration, when they are very fluid, as is the case with the juice of purslain, houseleek, &c. B By white of egg, which collects the fecula, by coagulation, as is requisite with the juice of borage, nettle, &c. C By simple heat, which coagulates and precipitates the parenchyma, as Mr. Baumé advises, with respect to juices that contain volatile principles, such as those of cochlearia, cresses, &c. The phial which contains the juice, being covered with a perforated paper, must be plunged in boiling water, and taken out as soon as the juice is clarified. Immersion in cold water brings it to a proper temperature for filtration; D By spirit of wine, which coagulates the fecula; E By vegetable acids, as the London Pharmacopeia prescribes for the juices of cruciform plants.

The juices of plants hold in solution matters which, when separated from the aqueous vehicle, form what, in pharmacy, are called extracts. These are distinguished into three kinds; mucilaginous, saponaceous, and gum-resinous extracts.

Mucilaginous extracts, are such as readily dissolve in water, scarcely at all in spirits of

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wine,

wine, and undergo spirituous fermentation: such is the rob of gooseberries, prepared by evaporating the juice of that fruit.

Saponaceous extracts are distinguished by solubility in water, and partly in spirit of wine; they become mouldy, instead of passing to the spirituous fermentation. The juice of borage, when converted into an extract, is of this nature; and these are extracts properly so called.

Gum resins dissolve in water, and in ardent spirit; they are inflammable, by virtue of the resinous principle they contain, and are not changed by exposure to air. The concentrated juice of wild cucumber, called elaterium is of this kind. Incisions are made in the fruit; and the expressed juice being suffered to clarify, by repose, is evaporated to dryness on the water bath.

Extracts of these three different species are prepared, in the large way, by evaporating the juices of several plants. Such, among others, are,

1. The juice of acacia, imported from Egypt, where the fruit of this tree is mashed, pressed, and the juice exposed to evaporation by the sun's heat. The inspissated juice of floss is prepared, in Germany, by a similar process, and sold under the same denomination.

2. That of hypocistis, which is made like the

the foregoing, with the fruits of this parafitical plant.

3. Opium, an important medicine, whose nature is not accurately known. It is extracted from the white poppy, in Persia, &c, where it flows through incisions made in the green capsules of the plant, in the form of a white juice, which dries into brown tears of the true opium. The opium of commerce is obtained, by pressure, from these capsules, moistened with water, and comes to us in a dry form, in flat circular cakes, wrapped up in leaves, and mixed with many impurities. It is purified by solution in as small a quantity of water, as is sufficient to suspend it; which being filtered, or strained by strong pressure, is evaporated on the water bath. This is the extract of opium, and contains a saponaceous extract, a solid essential oil, an odorous, noxious, and narcotic principle, an essential salt, and a glutinous matter. As the odorant, poisonous and narcotic principle, is often productive of bad effects, attempts have been made to obtain an extract of opium, deprived of this principle. Mr. Baumé, who has made many experiments on opium, volatilized this principle, together with the essential oil, and by that means separated the resin, after a digestion of six months. Bucquet has discovered, that the same sedative extract, without the narcotic property, may be obtained



by dissolving opium in cold water, and evaporating the solution in a water bath. Lorry, who has made successful inquiries into this subject, finds, that opium, after fermentation, affords a distilled water, which has the sedative property, without producing the bad effects of the crude substance, and which he has used with great success. He observes, that the odorous principle of this medicine cannot be destroyed by any process.

When the plants, from which it is proposed to make extracts, are dry and ligneous, maceration, infusion, or decoction in water, are employed, according to the state and nature of the materials: maceration is, in most cases, sufficient. Odoriferous plants must be only infused; decoction extracts too much, and separates the resinous parts, forming a thick fluid, which becomes turbid on cooling. Infusion may be used, in all cases, according to the opinion of the most celebrated physicians and chemists.

Water extracts various products from several plants. Thus the berries of juniper afford a mucilaginous extract; quinquina affords a saponaceous extract, in small transparent scales, resembling salts, if the evaporation be made in very shallow vessels; and rhubarb affords a gummy resinous substance.

The saponaceous, or more properly the  
chemical

chemical extract, appears to be a compound of oil and fixed vegetable alkali. The extracts, prepared in pharmacy, are very far from being all of the same nature; they are mixed with mucilage, essential salt, saccharine juice, resin, &c. From these considerations, Rouelle, with the intention of illustrating this part of medical chemistry, distinguished them into the three genera we have mentioned: but the pure extract, reckoned among the immediate principles of vegetables, must be considered as a saponaceous compound, possessing peculiar properties.

Extracts are prepared in the large way, in commerce, by means of water. Such as,

1. The yellow juice of liquorice, by the first infusion, or black, by strong decoction. This last is burned, and contains a true charcoal. It is purified by solution in water, filtration, and evaporation, usually with the addition of some essential aromatic oil of anniseed, cinnamon, &c.

2. The cachou, or, as it is improperly called, Japan, earth, is prepared in the East Indies, from the infusion of the seeds of a kind of palm, called areca, the infusion being evaporated, and made into cakes. It is purified by solution in water, and evaporation, usually with the addition of aromatics.

Among the extracts prepared for medical use, Rouelle particularly distinguished those

which are mixed with resin, by the names of gum resins, and resinous extracts.

Gum resins do not burn without being first dried, and appear to contain a larger quantity of extract, properly so called, than of resin. The resinous extract burns much better, and appears to contain more resin, than extractive matter. This happy distinction shews, that the two species consist simply of mixtures of extract with different doses of the resinous principle. They are not, therefore, with propriety called extracts, that name being applicable only to the saponaceous matter, whose properties we shall proceed to enumerate.

The pure extract differs from the foregoing: it is a dry, solid, brownish red, transparent substance, which does not burn by itself, but emits plentiful fumes, and contains more or less essential salt. Its taste is almost always bitter; by distillation, it affords an insipid phlegm; this phlegm, by a mild heat, becomes gradually of a deeper colour, and assumes alkaline properties, as is observable with elaterium, extract of borage, &c. The volatile alkali is formed by the heat; a small quantity of empyreumatic oil next comes over; and the coaly residue, which is light and porous, contains alkali, and almost always neutral salt. The extract, exposed to air, becomes mouldy, and attracts moisture; the salt it contains crystallizing,  
and

and separating from the extractive part. They are often changed, and intirely decomposed. It dissolves in water; producing the appearance of a strong infusion. Acids decompose this solution, in the same manner as they do soaps, and disengage a principle more or less oleaginous. Metallic solutions likewise separate this principle, by double affinity. The chemical properties of extract have not been farther examined into; but those that are already known, evince, that it is with great propriety considered as a kind of soap.

Extracts are used in medicine as aperitive, solvent, diuretic, stomachic, remedies, and are daily administered with great success.

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#### C H A P. IV.

##### Essential Salts.

**T**HE saline substances, held in solution in the juices of plants or the water wherein they are infused, are called essential salts of plants. They are obtained by cooling those fluids, which are first evaporated to the consistence of syrup. As these salts are impregnated with extractive, and fat matter, it is necessary to purify them with lime and



whites of eggs. If these salts be of an acid nature, lime must not be used, because it would neutralize them, but pure white clay in powder. After the first extraction, they are still very impure. Solution in distilled water, and crystallization, may be repeated till they become pure and white.

The essential salts of plants are of a different nature, and may be distinguished into two classes.

#### CLASS I. Of Essential Salts.

The first class includes those which resemble mineral salts. The principal species are, 1. Cretaceous fixed alkalis, which are obtained from almost all plants, by macerating them with acids, as Margraff and Rouelle the younger have shewn. The vegetable alkali is the most common, but the mineral alkali exists in marine plants. 2. Vitriolated tartar, or vitriol of pot-ash, in millefoil, in astringent and aromatic plants, in spurge flax, and in the mark of olives. 3. Glauber's salt, or vitriol of soda, from tamarisk. 4. Nitre, from borage, turnsole, tobacco, &c. 5. The febrifuge salt of Sylvius, or muriate of pot-ash; and marine salt, or muriate of soda, in marine plants. 6. Selenite discovered by Model in rhubarb.

Many other salts will doubtless be found, resembling those of minerals, when a greater number

number of plants shall be accurately analyzed. It has likewise been thought that volatile alkali; or rather ammoniacal chalk, exists ready formed in cruciferous plants; because these plants, by distillation, afford on the first application of heat, a phlegm which holds a small quantity of that salt in solution. On this account the ancients called them animal plants; but Rouelle the younger has shewn, that this salt does not exist ready formed in plants, but is produced by the re-action of the principles, which is promoted by heat. Mr. Baumé pretended that the volatile principle of cruciferous plants is nothing but sulphur. The volatile alkali obtained from these plants, arises from the inflammable gas of the oil united to the mephitis contained in the vegetable, as Mr. Berthollet has shewn.

Various opinions have been held, respecting the mineral salts found in plants. Some have thought, that these salts were conducted from the earth by water, and passed into the vegetables without alteration. Others have supposed, that the saline substances were formed by the process of vegetation. It is certain, that two very different plants growing in the same soil, as for example, borage and millefoil, afford each the salt peculiar to itself; that is to say, the borage affords nitre, and the millefoil vitriolated tartar. A single experiment, which has been much talked

talked of, but never accurately made, would decide the question; namely, to cause such plants as afford a certain salt, for example, nitre, to grow in a quantity of earth, previously lixiviated, and to water them with water containing marine or some other salt. If the plants in these circumstances afford nitre, and not marine salt, it might be concluded that the salt does not pass as such into the organs of plants, and that the proper salt is formed by the process of vegetation.

## CLASS II. Of Essential Salts.

The second class contains such salts as are peculiar to vegetables. These truly essential salts always consist of an acid united with an alkali, or an oil. The acid is often in a disengaged state, though sometimes masked by other substances.

The essential acid salts of vegetables are found in a great number of plants, and are afforded, in general, by all those which have a sour taste. Such are sorrel, acid fruits, lemons, oranges, &c. The salt best known of this kind in commerce, is called salt of sorrel. It has been long supposed to have been obtained from the aleluia, or oxys, but it is now affirmed to be really extracted from a kind of sorrel, in many parts of Switzerland. This salt has the form of white irregular crystals,

crystals, of a sharp taste, and reddens blue vegetable colours,

It dissolves readily in water, and may be crystallized without losing its acid. By heat, in a crucible, it exhales a strong acid smell, becomes carbonaceous, and takes fire. Its flame is blue, like that of spirit of wine, and leaves, after its combustion, a white salt, which with spirit of salt forms marine salt. An ounce of this salt afforded Mr. Baumé, by distillation, three drachms and a half of an acid colourless liquor, with a slight smell of marine acid. No oil passed it over; the residue was coaly. This salt precipitates the nitrous solution of mercury, as does likewise the acid it affords by distillation. The latter, mixed with the nitrous acid, did not dissolve. Bergman places the acid of sorrel as a peculiar acid, in the thirteenth column of his table of affinities. He differs from Baumé in certain particulars, though he agrees with him in most, as we shall observe; but he has not said whether his experiments were made with the salt of sorrel in commerce, or the true essential salt of sorrel. The following is an extract of his doctrine respecting this substance. Salt of sorrel consists of the vegetable alkali, supersaturated with a peculiar acid. Scheele has contrived a very good method of obtaining this acid salt. He mixed the oxaline acid, saturated with volatile alkali, with a solution  
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of ponderous earth, in the nitrous acid : the principles of these two compounds were mutually changed by double affinity ; the ponderous earth uniting with the oxaline acid, forming the barytic oxate of Mr. De Morveau, and falling to the bottom, on account of its difficult solubility. This precipitated salt is decomposed by the vitriolic acid, which has a stronger affinity with ponderous earth than any substance hitherto known. The oxaline acid remains disengaged in the supernatant liquor, which is decanted from the ponderous spar, formed during the decomposition. This salt seems to resemble the acid of sugar, rather than that of tartar, though it differs from both. For, when combined with a small quantity of vegetable alkali, it forms salt of sorrel, similar to that of tartar ; but which decrepitates in the fire, melts, becomes almost black, and capable of being totally decomposed by chalk : these properties are not found in tartar. A small proportion of vegetable alkali combined with acid of sugar, resembles neither tartar nor salt of sorrel. The oxaline acid prefers lime to alkalis ; but it is yet uncertain whether ponderous earth and magnesia have likewise a stronger affinity to this acid. It decomposes selenite ; because it has a stronger affinity than the vitriolic acid with lime. If the oxaline acid be strongly heated, it is destroyed ; but it neither swells, nor be-  
comes

comes so black, as the acid of tartar. By distillation, it affords a phlegm, much more acid than that which is obtained from the latter by the same process. From these circumstances we may perceive, that the difference between Bergman and Baumé, consists in the former admitting the vegetable alkali as the base of this salt; whereas the latter chemist found it to contain salt of soda.

All the acid salts of plants have not yet been examined, though a great number is known. The acid of lemons may be separated from its mucilage by standing, and concentrated by the action of frost, as Mr. Georgius has shewn; or by evaporation, carefully conducted. It has been thought analogous to the acid of tartar, though its stronger taste seems to indicate a resemblance with the oxaline acid. Stahl affirms this acid, saturated with crab's eyes, and digested with a small quantity of spirit of wine, gradually assumes the nature of vinegar. Bergman observes, that the acids of spar, phosphorus, arsenic, borax, sugar, tartar, sorrel, and lemons, resemble each other, in being scarcely at all soluble when combined with earths; and that they only become so, by means of an excess of acid; a property which is not found in other salts. Yet selenite and ponderous spar, two earthy salts, formed by the vitriolic acid, are scarcely soluble in water.

Fruits,

Fruits, which are at first sour, and become sweet as they ripen, afford a salt, whose acid is less developed than that contained in the foregoing substances. This salt seems to occupy the middle place between the very acid essential salts, and the saccharine matter, and resembles the tartar of wine. It is obtained from apples, pears, quinces, tamarinds, &c. Rouelle the younger, has examined it carefully in many of these vegetables. We shall speak more largely concerning it when we attend to the spiritous fermentation.

Modern chemists seem inclined to think, that all the acids of four fruits differ from each other, and compose particular species. Bergman and Scheele are of this opinion. The latter succeeded in crystallizing the acid of lemons, by saturating the juice with chalk, and decomposing the salt by the addition of vitriolic acid; the acid of lemons is disengaged in the supernatant liquor, and may be obtained in crystals by evaporation and cooling. We shall hereafter see, that this crystallized acid differs from lemon juice, and does not afford the same result with the nitrous acid.

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C H A P. V.

## Concerning the Saccharine Matter.

**T**HE saccharine matter, which many chemists consider as a kind of essential salt, is found in a great number of vegetables, and may be properly ranged among their immediate principles. The maple, the birch, the red beet, the parsnip, the grape, wheat, &c. contain it. Margraff extracted it from most vegetables. The petals of many flowers, and the nectariums placed in those organs, elaborate a principle of this kind.

The sugar cane, *arundo saccharifera*, contains it in larger quantities, and affords it more readily, than any other plant. The ripe canes are crushed between two iron cylinders, placed perpendicularly. The expressed juice falls on a plate beneath, and is called melasses. It flows into a caldron, where it is boiled with wood-ashes and lime, and the scum taken off. This boiling with ashes and lime is repeated in three other boilers, and converts it into syrup. It is then strongly boiled with lime and alum; and when it is sufficiently concentrated, it is poured into a vessel called the cooler.

When



When it is cooled so that the finger may be plunged into it without injury, it is poured into barrels placed over certain cisterns, and pierced at the bottom with many holes, stopped with canes. The syrup becomes solid in the casks, and part flows out through the holes into the cistern beneath. The sugar in this concrete state is yellow and greasy; it is called muscovado. It is refined in the sugar islands by boiling, and pouring into inverted earthen cones, called pans. That part of the sugar which is incapable of becoming concrete, runs through the aperture of the pan into a pot placed beneath. The base of the sugar loaves is taken away, and white sugar in powder is put in its place, and pressed down; the whole is then covered with moistened clay. The water of the clay filtrates through the sugar, and carries with it a portion of the mother water, which runs out through the aperture at bottom, and is received in other pots. A second covering of clay is put on when the first is dry, and the water is suffered to filter through a second time; after which, the loaves are carried to a stove to dry. At the end of eight or ten days these loaves are broken, and the powdered sugar is conveyed to Europe, where it is refined into sugar of different qualities.

The process of refining consists in boiling the sugar in lime-water, together with bullocks

locks blood, taking off the skim three or four times, and filtering the liquor, which is then poured into pans to make loaves. The loaves are covered with a stratum of moistened clay, and the water is thus filtered through the sugar, by the repeated addition of a new stratum of clay as the former becomes dry, until the sugar has acquired the requisite degree of whiteness. The loaves of refined sugar are then conveyed into a stove, and at the end of eight days are wrapped in paper, and tied up for sale. The remaining syrup, which cannot be crystallized, is sold under the name of melasses.

All chemists formerly supposed, that these different operations separate a fat matter from sugar, and by that means render it susceptible of crystallization. Bergman thinks, that lime serves to deprive it of that excess of acid, which prevents its taking the solid form. As it is quickly evaporated during the whole process, it takes the form of a granulated and irregular mass, in the same manner as we have before observed with respect to the vitriol of zink.

Sugar consists of a peculiar acid united to a small quantity of alkali, and much fat matter. It crystallizes in hexahedral truncated prisms, and in this state is called sugar-candy. By distillation, it affords an acid phlegm, and a few drops of empyreumatic oil. The residue is a spongy light coal, which con-

tains a small quantity of vegetable alkali. This salt is inflammable. On hot coals it melts, and swells up very much, emits a penetrating vapour, and becomes converted into a brown yellow matter called caramel. It is very soluble in water, to which it gives much consistence, and constitutes a kind of mucilage, called syrup. Syrup, diluted with water, is capable of fermentation, and affords ardent spirit.

Bergman has obtained, from all saccharine matters, especially sugar, an acid of a peculiar nature. For this purpose, one part of sugar in powder is mixed in a retort with six parts of aqua fortis, and a gentle heat is applied. The evaporation is continued for some time after the red vapours have ceased. The solution being suffered to cool, affords white crystals in the form of four-sided needles or prisms, terminated with diheral summits. The decanted liquor treated a second time with three or four parts of the same nitrous acid, affords, by a new crystallization, prisms of the same form. The operation is again repeated on the second mother water. An ounce of white sugar, by this process, affords about three drachms of prismatic salt; which is dissolved in hot water, and crystallized by cooling, in order to obtain it in a state of purity.

The acid of sugar has a very penetrating sour taste. Diluted with water, it forms  
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an agreeable acid liquor. It reddens all blue vegetable colours. Exposed to a mild heat, it becomes opake, and falls into a powder, resembling efflorescence, and loses three-tenths of its weight, by the evaporation of the water which enters into its crystals. This water may be collected by the usual apparatus for distillation. A stronger heat fuses the acid, and gives it a brown colour; an acid phlegm passing at the same time into the receiver, similar in all its properties to the salt itself. Part sublimes in the form of a white crust; and the retort contains scarcely any residue. The residue is grey or brown, and does not amount, according to Bergman, to more than the fiftieth part of the original matter. A very considerable quantity of a gaseous substance is likewise afforded in this operation: half an ounce of the acid of sugar afforded Bergman 100 cubic inches of gas, half of which was cretaceous acid, and the other half inflammable gas, which burned with a blue flame. The Abbé Fontana, who repeated this experiment, obtained from an ounce of the crystallized salt, 432 inches of gas, of which one third was cretaceous acid, and the rest inflammable gas, mixed with common air. On repeating the same experiment, I had a result nearly agreeing with that of the latter chemist. The most singular circumstance is, that the sublimed portion distilled for two more successive times



affords no coaly matter, but only a residue of a whitish grey colour. This salt heated in an open fire, emits a very penetrating vapour, and leaves a residue which is perfectly white.

The acid of sugar exposed to the air, effloresces in process of time.

Cold water dissolves half its weight of this salt; but boiling water dissolves double the quantity. The salt crystallizes as it cools.

The acid of sugar dissolves the base of alum. The evaporated solution affords a yellowish, transparent, sweet, astringent, matter, which becomes moist in the air, and reddens turnsole. This salt boils up in the fire, loses its acid, and leaves the clay of a brown colour. It is decomposable by mineral acids.

The acid of sugar, combined with ponderous earth, forms a salt scarcely soluble, which affords angular crystals, when the acid is in excess. Hot water, by carrying off this excess, renders them opaque, pulverulent, and insoluble.

When combined with magnesia, it affords a white salt in powder, decomposable by the sparry acid, and by ponderous earth.

Saturated with lime, the acid of sugar affords a pulverulent salt insoluble in water, and not decomposable but by fire; because the affinity of this acid with lime is such, that it takes it from every other. Bergman, consequently,

consequently, proposes the acid of sugar as a test to discover the presence and quantity of lime contained in mineral waters, whether disengaged, or in combination with any acid. This salt turns syrup of violets to a green.

The acid of sugar unites with the vegetable alkali, and may be crystallized, provided either of the principles be in excess. This salt, which is very soluble in water, is decomposable by the action of fire, and by the mineral acids.

Combined with two parts of soda, the acid of sugar forms a salt of difficult solubility, which dissolves more readily in hot than cold water, and turns syrup of violets to a green.

With the volatile alkali it affords an ammoniacal salt, which by slow evaporation, crystallizes in quadrilateral prisms decomposable by fire, and convertible into cretaceous ammoniacal salt, formed by the destruction of the saccharine acid.

The acid of sugar is soluble in the mineral acids. It gives a brown colour to oil of vitriol, and is decomposed by smoking spirit of nitre.

In general, it combines more readily with metallic calces than with metals.

1. With white arsenic it forms very fusible, volatile, prismatic crystals, decomposable by heat.

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2. With

2. With cobalt, a pulverulent salt of a light rose colour, and difficultly soluble in water.

3. With calx of bismuth, a white salt in powder, of difficult solubility.

4. With calx of antimony, a salt in crystalline grains.

5. With nickel, a white or greenish yellow salt, of difficult solubility.

6. With manganese, a salt in a white powder, which becomes black by heat.

7. With zink, which it dissolves with effervescence, it forms a white pulverulent salt.

8. With calx of mercury, a white pulverulent salt, which becomes black by the contact of light. This acid decomposes the vitriol and nitre of mercury.

9. It at first blackens tin, which afterwards becomes covered with a white powder. The salt it forms with this metal is of an acrid taste, and by a well-conducted evaporation, crystallizes in a prismatic form. If quickly evaporated, it affords a transparent mass resembling horn.

10. It tarnishes lead, but dissolves the calces much more readily than the metal itself. The saturated liquor deposits small crystals, which may likewise be obtained by pouring the acid of sugar into a solution of the nitre, or the muriate of lead, as well as into the acetous solution of that metal.

11. It

11. It attacks iron filings, and produces inflammable gas. This solution is styptic, and affords prismatic crystals, of a greenish yellow, decomposable by heat. The saffron of Mars, united to this acid, presents a yellow powder, similar to that which is obtained by pouring the fluid acid of sugar into a solution of martial vitriol.

12. It acts on copper, and completely dissolves the calces of that metal, forming a salt of a light blue colour, and of difficult solubility. This salt may likewise be obtained by precipitating the solutions of copper in the vitriolic, nitrous, muriatic, and acetous acids, by the addition of the acid of sugar.

13. The calx of silver, precipitated by vegetable alkali, is sparingly dissolved in this acid. The best manner of procuring this salt, which Bergman calls saccharated silver, is to precipitate the nitrous solution of this metal by the acid of sugar: a white precipitate is formed, scarcely soluble in water, which becomes brown by the contact of light.

14. This acid has scarcely any action on the calx of gold.

15. Lastly, it dissolves the precipitate of platina, made by soda. This solution is yellowish, and affords crystals of the same colour. Such are the phenomena described



by Bergman, respecting the combinations of the acid of sugar with metallic substances.

It may be supposed, from the process of this celebrated chemist for obtaining the acid of sugar, that this salt is produced from the nitrous acid made use of. Bergman does not think that this opinion is admissible, because the acid of sugar has none of the properties of that of nitre, but on the contrary, differs from it in all its combinations. The nitrous acid does not, in fact, appear to enter into the acid of sugar; but the great quantity of nitrous gas emitted in this process, shews, that the spirit of nitre is decomposed. Now, since the nitrous acid, according to the experiments of M. Lavoisier, does not afford nitrous gas, but in proportion as it loses the base of pure air, it appears that a part of its oxygenous principle combines with the combustible matter of the sugar, to form the acid obtained. We have seen already, that the production of the arsenical acid, and of the dephlogisticated muriatic acid, may be explained in this manner.

Though, at the time of the first discovery of this acid, it was thought that the saccharine principle was necessary to its formation, it is at present known, that a great number of vegetables, which are not saccharine, afford it in greater or less abundance; such are gums, starch, vegetable gluten, salt of sorrel, lemon

mon juice, spirit of wine, and many animal matters, as Mr. Berthollet has discovered. Among these substances, those which produce the greatest quantity of this peculiar acid, by the action of spirit of nitre, are such as do not afford sugar. Pure sugar did not afford Bergman more than one-third of its weight of acid; and Mr. Berthollet obtained more than half from wool. It seems, therefore, as M. De Morveau thinks, that this acid is formed by the union of a peculiar attenuated oil, which exists in all organic substances; and is the same throughout; and that consequently the name of saccharine acid is improper. Mr. Scheele has observed, that the acid of lemons, crystallized by the process described in the foregoing chapter, does not afford saccharine acid, by treatment with nitrous acid, though lemon juice itself affords it. The vitriolic acid, employed for the purification of this acid sugar, seems, therefore, to decompose the oil which forms the base of the saccharine acid.

Sugar is very extensively useful. It is a food which, taken in too large a quantity, is capable of heating the animal system. It is very much used in pharmacy, where it is the base of syrups, lozenges, and other preparations. It is very useful, as a medium to favour the solution or suspension of resins, oils, &c. in water. It preserves the juices  
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of fruits, after they are reduced into a jelly. It may even be considered as a medicine, since it is incisive, aperient, slightly tonic, and stimulant; and there are, accordingly, instances of disorders, arising from obstructions, which have been cured by the habitual use of sugar.

Certain juices, which flow out of plants, have a saccharine taste. Manna and nectar are of this kind. Manna is produced by the leaves of the pine, the oak, the juniper, the willow, the fig-tree, the maple, &c. The ash, which is very abundant in Calabria, Sicily, &c. affords the manna in commerce. It flows naturally from these trees, but is much more abundantly obtained by making incisions in their bark. That which is collected on chips of wood, or small sticks, introduced into the artificial apertures, forms a kind of stalactites, perforated within, and called manna in the tear. Manna, in flakes, flows on the bark, and contains some impurities. The inferior, unctuous sort, contains many foreign substances, and consists of the refuse pieces of the two former kinds: it is always moist, and frequently adulterated. The taste of manna is sweet, and slightly nauseous. The manna afforded by the larch tree, which abounds in Dauphiny; and that of the alhagi, which grows in Persia, (*Hedysarum* Linn.) in the neighbourhood of Tauris, are not used;

used: the latter bears the name of tereniabin. Manna is soluble in water, and affords, by distillation, the same products as sugar. Treated with lime, and white of eggs, it affords a substance resembling sugar; and by the process already described with the nitrous acid, it affords an acid of the same nature as is obtained from sugar.

It is used as a purgative, in the dose of from one to two, or three ounces; or in the dose of a few drachms, diluted, as an alterative.

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## C H A P. VI.

### Concerning Gum and Mucilage.

**A**NOTHER kind among the proper juices of plants, is that called gum, or mucilage. This substance is very abundant in the vegetable kingdom. It is found in a great number of roots; the young shoots, and new leaves, contain it in large quantities. This principle may be known by its viscous and adhesive quality, when these parts are crushed between the fingers. At the time of the year when the juices are most abundant, it naturally exsudes through the bark of trees, and thickens at the surface into gum. Gum is soluble



soluble in water, to which it gives a thick and viscous consistence. This solution, known by the name of mucilage, becomes dry, transparent, and brittle, by evaporation.

Gum burns without any sensible flame; it melts, and boils up on hot coals; by distillation, it affords much acid phlegm, a small quantity of thick and brown oil, and cretaceous acid, in the state of elastic fluid. Its coal is very bulky, and contains a small quantity of the fixed vegetable alkali.

Three kinds of gum are used in medicine, and in the arts.

1. Gum, which flows from the apricot, pear, plumb trees, &c. It is white, yellow, or reddish; and when well selected, may be applied to the same uses as other gums. A kind of gummy juice, of a beautiful yellow colour, flows from the elm, and is sometimes found in considerable quantities on its bark. I find this gum to be insipid, soluble, viscous, and to possess all the characters of juices of this nature.

2. Gum arabic, which flows from the acacia in Egypt and Arabia. Gum senegal is of the same nature: it is used in medicine as a softening and relaxing remedy; it gives consistence to crayons, and is used in several arts.

3. The gum tragacanth, which flows from the adragant of Crete; *tragacantha cretica*.

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It is administered in the same cases as the foregoing. Its solution is somewhat thicker and it requires more water to dissolve it than the other gums. Viscous flakes are deposited from its solution.

Mucilages, of the same nature as gums, are obtained from many plants. The roots of mallows, the greater comfrey, the bark of elm, linseed, the seed of quinces, &c. afford viscous fluids, by maceration in water, which, by evaporation, leave true gums. The decoction of these plants is substituted, in medicine, instead of gums.

All these substances, chemically considered, seem, at first sight, to be bodies not much composed, since chemical experiments often exhibit substances, which, by their gelatinous form, seem to resemble gums and mucilages. Yet, from these vegetable products, which seem to constitute an excrementitious humour, are obtained water, liquid acid, cretaceous acid, an oily principle, and fixed alkali, united to a coaly residue. This residue contains likewise a fixed earth, whose nature is not yet known.

When gums and mucilages are treated with the nitrous acid, they afford a crystallized acid, of the same nature as that which is improperly called acid of sugar. It appears, therefore, that they contain the oily principle, whose combination with the oxygenous

ginous principle constitutes this species of acid.

The analogy between mucilage and saccharine matters, is likewise observable in the fumes of burned gum, which in smell resemble that of calomel, as well as by the nature of the products both afford by distillation, and the porosity and lightness of their residual coal. Among fruits which become saccharine, there are some, as for example, apricots, pears, &c. from which, before the time of their maturity, a true gum exsudes. The kind of dry mucilage, which we shall hereafter describe, under the name of amylaceous fecula, is converted into saccharine matter by germination. These facts, and many others which might be urged, shew, that there is a strong resemblance between sugar and gum. The insipid and gummy mucilage may perhaps pass to the state of sugar, by a kind of fermentation. If the fact were established, it would be proper to place this fermentation before that which Boerhaave has distinguished by the name of spirituous; and it would always precede it, whether in the process of vegetation, or in those operations which are artificially made to produce the saccharine taste in barley, &c.

## C H A P. VII.

## Of Fat Oils.

**O**ILS are proper juices of a fat and unctuous nature, either solid or fluid, indissoluble in water, combustible with flame, and volatile in different degrees; they are contained in the proper vessels, or in peculiar vesicules. These substances are found in two states in vegetables; either combined with other principles, as in extracts, mucilages, &c. or at liberty. Our attention must at present be directed to the latter.

Chemists have supposed the existence of a simple oily principle, as well as of a primitive salt. This oily principle, combined with different substances, and modified by these combinations, constituted, according to them, the different species of oils obtained in the analysis of vegetables. The characters attributed to this simple and primitive oil, were great fluidity and volatility, neither colour nor smell, combustibility with flame and smoke: it was said to be incapable of uniting with water, and to consist of an acid combined with an earth and phlogiston.

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It is certain that oils, in their decomposition, always afford a small quantity of acid, and much inflammable gas; the earth forms but a small part, as they leave but an inconsiderable quantity of fixed and coaly residue. This notion respecting the oily principle, must be considered as a mere hypothesis.

Oils are never formed but by organic bodies, and all substances in the mineral kingdom, which present oily characters, have originated from the action of vegetable or animal life. It is even very probable, that they are only formed in vegetables, and that they pass without alteration into animal substances.

The oily juices of vegetables are distinguished into fat oils and essential oils.

Fat oils are very unctuous; their taste is commonly mild and insipid, and they have no smell; they are not volatilized but by a heat superior to that of boiling water, and do not take fire till heated sufficiently to volatilize them. The wick which is used to burn fat oil in lumps, answers this purpose; it heats the oil to such a degree, as volatilizes it.

Most fat oils are fluid, and require a considerable degree of cold to congeal them; others become solid by a very slight degree of cold; and others again are almost always solid: these last are called butters.

Fat oils are not emitted from the surface of vegetables, but are contained in the kernels,

nels, the pippins, and emulsive seeds. They are extracted by breaking the cellules by which they are enclosed; that is to say, by pounding and pressure.

Fat oils exposed to air are changed, and become rancid; their acid becomes developed, and they lose their properties, at the same time acquiring others, by which they more nearly resemble essential oils. Water and spirit of wine, by washing off this disengaged acid, deprive them of their strong taste, but never restore their original state.

Mr. Berthollet has discovered, that fat oils thinly spread on the surface of water, and exposed to the air, become thick, and resemble wax. This appears to arise from the absorption of the base of vital air.

By distillation they afford an acid phlegm of a penetrating smell, a light oil, a denser oil, and a large quantity of inflammable gas mixed with cretaceous acid. The quantity of residual coal is not abundant. By redistilling these, more phlegm, and an oil which becomes lighter each time, are obtained. This is known by the name of philosophical oil; the alchemists prepared it by distilling, for several successive times, an oil with which they had impregnated a brick. It is not exactly known how far this decomposition may be carried, though it is said that fat oil may this way be reduced into the disengaged inflammable principle, acid, phlegm, air, and earth.

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Water

Water does not produce any change in fat oils in the cold, but it purifies them, by carrying off part of their mucilage, which is likewise precipitated during their combustion, and is the cause of their property of fermenting and becoming rancid. It is well known, that water thrown on burning oils, causes them to give a stronger flame, instead of extinguishing them. This depends on the vital air afforded by the decomposition of the water, which affords the base of vital air. When the vapour of the flame of burning fat oil is collected in a chimney, terminated by a worm pipe, a large quantity of water is obtained: whence it follows, that this immediate principle of vegetables contains an aqueous inflammable gas.

Fat oils do not combine with siliceous earth: with clay they form a soft paste used in chemistry, by the name of fat lute.

By particular processes they combine with magnesia, which reduces them to a saponaceous state.

Lime unites with oils, but not in a very evident manner when the substances are immediately applied to each other.

Pure alkalies combine readily with fat oils, and produce a compound called soap.

To prepare this compound, oil of olives, or of sweet almonds, is triturated with a concentrated lixivium of soda, rendered caustic

tic by lime, and known by the name of soap lye. The mixture becomes thick in a few days, and is converted into the soap used in medicine. The soap of commerce is made by boiling the lixivium with rancid oil; it is then white, but is marbled by martial vitriol. Green soap is made with the marc of olives and pot ash.

Soap is soluble in pure water; heat decomposes it, and disengages phlegm, oil, and volatile alkali produced from the fixed alkali and the oil; the coal contains much fixed alkali. This artificial composition of volatile alkali seems to prove, that fixed alkalies contain mephitic, which reacts on the inflammable gas of the oil.

Lime-water decomposes soap, according to the observation of Mr. Thouvenel; an insoluble calcareous soap is then formed, which is deposited in grains. Acids poured on soap disengage the oil, but somewhat altered.

The volatile alkali does not combine with fat oils without difficulty; yet, by long trituration the mixture becomes opaque, and rather more consistent.

Fat oils unite with acids, and form peculiar soaps, when the acid made use of is weak. Messrs. Achard, Cornette, and Macquer, have made experiments respecting these compounds. Mr. Achard added concentrated vitriolic acid, by small portions, to fat oil.



This mixture being continually triturated, becomes at length converted into a brown mass, soluble in water and spirit of wine. The oil obtained from this soap by alkalies, as well as by distillation, is always more or less concrete. Mr. Macquer advises, in making this soap, to pour the acid on the oil; but he observes, that an acid soap made in this manner, is scarcely soluble in water. The soap which is prepared by triturating common alkaline soap with oil of vitriol, is more soluble. The concentrated vitriolic acid renders fat oils black, and causes them to resemble bitumens. This phenomenon appears to arise from the re-action of the inflammable gas of the oil on the oxygenous principle of the vitriolic acid.

The fuming nitrous acid immediately changes fat oils to a black colour, and inflames such as are of a drying nature. Those which do not dry cannot be inflamed, but by a mixture of spirit of nitre and oil of vitriol, as Rouelle the elder has shewn in his Memoirs on the Inflammation of Oils, printed among those of the Academy for the year 1747.

The muriatic and cretaceous acids, act but weakly on fat oils; the former, however, in a concentrated state, combines with them to a certain degree, according to Mr. Cornet. The dephlogisticated muriatic acid thickens them much, and appears, by the absorption

absorption of its oxygenous principle, to convert them into a substance nearly resembling wax.

The action of the other acids on fat oils, is not known; these oils do not appear to combine with neutral salts. Many of the latter, more especially the calcareous salts, decompose alkaline soaps. In this decomposition, especially that effected by the vitriols of lime and magnesia, which are frequently contained in water, the vitriolic acid unites with the fixed alkali of the soap, and forms vitriol of soda; the lime or the magnesia combines with the oil, and forms a kind of soap scarcely at all soluble, which floats in whitish curd-like masses on the surface of the water. This is the cause of the common appearance produced by hard waters, when attempts are made to use them with soap.

The action of inflammable gas on fat oils has not yet been examined.

Fat oils dissolve sulphur in a boiling heat, and this solution is of a deep brownish red colour, of a very fetid smell, and gradually deposits sulphur in the crystalline form. When this combination is distilled, the sulphur is totally decomposed, and is no where found. This experiment well deserves to be carefully repeated. Sulphureous gas is likewise obtained in this decomposition.

Fat oils do not appear capable of uniting with pure metallic substances, excepting copper and iron, on which they have a considerable action. But they combine with metallic calces, and form thick, concrete combinations, of a soapy appearance, as may be observed in the preparation of unguents and plasters. These preparations have not yet been chemically examined; it is only known, that certain metallic calces are reduced in the formation of plasters; as for example, the calces of copper and lead, &c. In docimastic operations, fat oils are used to reduce metallic calces. Mr. Berthollet describes an ingenious and simple process, for immediately combining a fat oil with any metallic calx, in the saponaceous form. It consists in pouring a solution of soap into a metallic solution; the acid of the latter seizes the fixed alkali of the soap, and the metallic calx is precipitated in combination with the oil, to which it communicates its colour. In this manner a beautiful green soap is formed with vitriol of copper, and a brown soap with vitriol of iron; these compounds may perhaps be useful in painting. M. Scheele has discovered, that by combining oil of sweet almonds, of olives, of rape, or of linseed, with the calces of lead, and adding a small quantity of water to the mixture, a substance is separated, which he calls the sweet principle. By  
evaporating

evaporating the water, this principle is obtained, of the consistence of syrup; by a strong heat it takes fire; part is volatilized in the distillation without burning; the residual coal is very light. The sweet principle does not crystallize, nor does it appear susceptible of fermentation; nitrous acid distilled four times from it, produces acid of sugar. This principle appears to be a kind of mucilage.

Fat oils dissolve bitumens, and in particular amber, but they require the assistance of heat. These combinations are a kind of fat varnish, which does not become dry without difficulty.

Fat oils may be distinguished into three genera.

The first comprehends pure fat oils, which congeal by cold, thicken slowly, form soaps with acids, and do not take fire by the nitrous acid, unless oil of vitriol be likewise used.

1. Such are oil of olives obtained from the pulp of that fruit, crushed between two mill-stones, and pressed in sacks made of rushes. The first product is called virgin oil; that which is obtained from the marc, moistened with water, is less pure, and deposits a sediment. The oil of unripe olives is the *oleum omphacine* of the ancients. Oil of olives freezes at 10 degrees below zero, on Reaumur's thermometer, or ten de-



degrees and a half above zero, in the thermometer of Fahrenheit, and does not become rancid in less than about twelve years.

2. Oil of sweet almonds extracted without heat, becomes quickly rancid; it does not freeze till its temperature is reduced to 6 degrees below 0 of Reaumur's scale, or 17 and a half of Fahrenheit.

3. Oil of rape obtained from the seeds of a kind of cabbage called colsa.

4. Oil of ben, extracted from the ben nut, from Egypt and Arabia; it is very acrid, inodorous, and freezes very easily.

The second genus comprehends drying oils, which soon become thick, do not congeal with cold, are inflamed by the nitrous acid alone, and form a kind of resin with vitriolic acid.

1. Such are linseed oil, obtained by pressure from linseed. It is used in oily varnishes, and in painting.

2. Nut oil applied to the same use.

3. Oil of poppy seeds, which is not at all narcotic, as the Abbé Rozier has clearly shewn.

4. Oil of hemp seed, which is very drying.

In the third genus we comprehend concrete fat oils, or butters, among which we may distinguish the following.

1. Butter of cocoa, obtained from the chocolate nut: four species of cocoa are distinguished;

distinguished; the large and small caracca, the berbice, and that of the islands. The butter is extracted by roasting and subsequent ebullition in water, and is purified by melting with a gentle heat.

2. The cocoa nut affords a butter of the same kind.

3. The wax of vegetables is of the same kind, excepting that it is more solid; it comes from China, where it is made into yellow, green, or white candles, according to the manner in which the wax is extracted. The catkins of birch and poplar, afford a small quantity of this kind of wax. That of Louisiana is more abundant; M. Berthollet quickly bleaches it with the dephlogisticated marine acid.

The use of fat oils in the arts, and in medicine, is very extensive. They are medically prescribed as relaxing, softening, and laxative remedies; some are even purgative, as the oil of Ricinus, or Palma Christi, which has been likewise discovered to possess the property of destroying and evacuating the solitary worm. They enter into many medical compounds, such as balsams, unguents, plasters, &c. they are often used as food, on account of the mucilage they contain.

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C H A P. VIII.

## Concerning Effential Oils.

**E**SSENTIAL oils differ from fat oils, by the following characters: Their smell is strong and aromatic: Their volatility is such, that they rise with the heat of boiling water: and their taste is very acrid. They are likewise much more combustible than the fat oils. These oils exist in most strong smelling plants. They are either contained in the whole plant, as in the Bohemian angelica, or in the root only, as in starwort, the iris, the white dittany, and the kidney-wort, &c.; or in the stem, as in the woods of sandal, saffras, pine, &c. or in the bark, as in cinnamon. In some, the leaves only contain it, as is observed in balm, peppermint, wormwood, &c. in other plants it is found in the calices of the flowers, as in the rose, and lavender. The petals of camomile and orange flower abound with it. In others again, it is contained in the fruits, as in cubebs, pepper, juniper berries, &c. Lastly, many vegetables contain this oil in their seeds, as nutmeg, anise, fennel, and most umbelliferous plants. Effential oils differ from

from each other, 1. In the quantity, which greatly varies according to the state or age of the plant. 2. In consistence: some are very fluid, such as those of lavender, blue, &c.; others congeal by cold, as the oils of aniseed, or fennel; others again are always concrete, as those of roses, parsley, kidney-wort, and starwort. 3. With respect to colour: some are colourless, others yellow, as that of lavender; others deep yellow, as that of cinnamon; others blue, as that of camomile; others sea-green, as that of St. John's-wort; or green, as that of parsley. 4. By their weight: some float on water, as most of the oils extracted from plants growing in temperate countries; others, as those of saffra and carraway seeds, and most oils from hot countries, sink to the bottom. This property is not, however, constant with respect to climates, the essential oils of nutmeg, pepper, and mace, being lighter than water. 5. With respect to smell and taste: this last property is often very different in the essential oil from that of the plant. For example, pepper affords a mild oil, and the oil of wormwood is not bitter.

Essential oils are obtained, 1. By pressure, from the cedra, from bergamot, from lemons, oranges, &c. 2. By distillation. For this purpose, the plant is put into a copper alembic, together with water; the water



water being made to boil, comes over together with the oil into the receiver, and is obtained separate by decantation.

Essential oils are adulterated either by the addition of fat oils, which may be known by the stain such oils make on paper; or by oil of turpentine, which may be distinguished by its strong smell, that remains after the essential oil is evaporated. The addition of spirit of wine in most cases discovers the adulterating substance which remains undissolved, while the oil unites with the spirit.

Essential oils lose their smell by a gentle heat, as they are very volatile; fire alone does not decompose them. When heated with contact of air, they quickly take fire, and emit a very thick fume, which becomes condensed into a fine and light coaly matter: they leave very little fixed coal after their inflammation; because they are so volatile, that the coaly matter is formed in the part which rises.

By exposure to the air they become thick, and in process of time assume the character of resin. Needle-formed crystals are deposited similar to those afforded by camphire when sublimed. Geoffroy the younger, observed them in the essential oils of motherwort, marjoram, and of turpentine. The same chemist observes, that their smell is similar to that of camphor.\*

They unite difficultly with lime and alkalis,

\* See the Memoirs of the Academy for the year 1721,

lis, and are changed by acids. The concentrated vitriolic acid converts them into bitumens; but if it be weak, it forms a kind of soap. The nitrous acid causes them to burst into flame; the muriatic acid renders them saponaceous; and the dephlogisticated marine acid thickens them.

They have no action on neutral salts.

They combine very readily with sulphur, and form compounds, called balsams of sulphur, in which the sulphur is so far changed, that it cannot be again recovered.

Mucilages and sugar render them soluble in water.

They are used as cordial, stimulant, antispasmodic, &c. remedies. Externally applied, they are powerfully antiseptic, and stop the progress of caries in the bones.

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## C H A P. IX.

Concerning the Camphorate Principle.

**C**Amphor is a white concrete crystalline matter, of a strong smell and taste, which resembles essential oils in some of its properties, and differs from them in others.

From a number of observations, chemists consider camphor as an immediate principle of vegetables, existing in all very odorife-

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rous plants, that contain essential oil. It has been obtained from the roots of zedoary, thyme, rosemary, sage, and other labiated plants, either by distillation or decoction, as Cartheuser and Neumann have observed; but this camphor is in small quantities, and always has the smell of the plant from which it is obtained. This singular substance seems to be combined with the essential oils of vegetables, as we may conclude from the observation of Geoffroy, mentioned in the foregoing chapter. M. Joffe, apothecary at Paris, shewed me a true camphor obtained from the roots of starwort. Lorry considered camphor as a principle abounding in vegetables, and placed its spiritus rector at the head of a class of very powerful smells, whose effects on the animal economy deserve the attention of chemists and physicians.

The camphor used in medicine, is obtained from a species of laurel which grows in China, Japan, and in the islands of Borneo, Sumatra, Ceylon, &c. The tree which produces it, sometimes contains so large a quantity that it need only be cleft, in order to obtain very pure tears of camphor, of considerable size. It is obtained by distillation. The roots, or other parts of the tree, are put into an alembic with water, which is covered with a capital, containing ropes of rice straw. On the application of a sufficient heat, the camphor

camphor is sublimed in small greyish grains, which are afterwards united into larger masses. This crude camphor is impure; the Dutch purify it by sublimation, after previously adding an ounce of lime to each pound of the camphor.

Camphor is much more volatile than essential oils and substances: with the most gentle heat, it crystallizes in hexagonal laminæ, attached to a middle stem. By a sudden heat it melts before it rises. It does not seem decomposable by this means; yet if it be repeatedly distilled, it affords a reddish and manifestly acid phlegm, which seems to shew that the whole might be decomposed by repeating the operation a sufficient number of times. The temperature of the air in summer volatilizes it, so that it is intirely dissipated. In a close vessel it sublimes in hexagonal pyramids, or polygonal crystals, which were observed and described in the year 1756, by Romieu. Its smell is strong and insupportable to some persons; it takes fire readily, burns rapidly with much smoke, and leaves no carbonaceous residue.

It does not dissolve in water, to which, nevertheless, it communicates its smell: it burns on the surface of water. Romieu has observed, that small pieces of camphor, of the third or fourth part of a line in diameter, on the surface of a glass of pure water,  
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have a rotatory motion, and are dissolved in the space of half an hour. He suspects that this motion is produced by electricity, and observes that it ceases when the water is touched with a body that conducts electricity, such as an iron wire; and that on the contrary, it continues, though the water be touched with an insulating substance, such as glass, resin, sulphur, &c.

Earths, the salino-terrestrial substances, and alkalis, have no action on camphor. It must, however, be observed, that experiments have not yet been made with the caustic alkalis.

Concentrated acids dissolve camphor. Oil of vitriol, assisted by heat, dissolves it, and becomes red. The nitrous acid dissolves it without any intestine motion, and forms a yellow liquid, which, because it floats on the acid, has been called oil of camphor. The muriatic acid, in the state of gas, dissolves camphor; as do likewise the sulphureous and sparry gases. If water be added to these solutions, they become turbid, and the camphor is separated in flocks, which float on the surface of the liquid, and does not appear to have sustained any change in its properties. Alkalis, and also the salino-terrestrial substances, and metallic matters, likewise separate camphor from acids.

Neutral salts have no action on camphor. The action of sulphur and bitumens on this substance

substance is not known, though it is probable they would unite with it.

Fat oils, and essential oils, dissolve camphor by the assistance of heat. These solutions, by cooling, gradually deposit crystals in a vegetation similar to that which is formed in solutions of sal ammoniac; namely, a middle stem, in which very fine horizontal threads are inserted. This kind of feathers, examined by the magnifier, is very beautiful and regular. Romieu was the first who observed this beautiful crystallization (*Memoirs of the Academy for 1756, page 448*). We shall hereafter see that the solution of camphor in spirit of wine, which is much better known and more used than the foregoing, presented this observer with a crystallization somewhat different, which he obtained by a peculiar process. Camphor is one of the most powerful remedies the art of medicine possesses. It dissipates inflammatory tumours in a short time, by external application. It is used as an antispasmodic, and as an antiseptic remedy in contagious disorders, putrid fevers, and in general, in all disorders which are attended with nervous affections, or putridity. It is not administered in France in larger doses than a few grains; in Germany, and in England, it is given in the quantity of several drachms per day. It is of importance to be known, that

camphor often mitigates heat and pain in the urinary passages, as it were by enchantment. It is given, triturated with yolk of eggs, sugar, gums, or in the state of oil of camphor; and is sometimes used in the composition of diet drinks. Surgeons use camphorated spirit of wine, whose composition we shall hereafter describe, in external gangrenes, and often with good success.

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## C H A P. X.

### Concerning the Spiritus Rector.

**B**Oerhaave gave the name of spiritus rector to the principle in which the smell of plants resides. The properties of this singular substance, so interesting on account of its effects on the animal economy, are yet but little known. The spiritus rector appears to be exceedingly volatile, fugacious, and attenuating. It is continually disengaged from plants, and forms an odoriferous atmosphere around them, to a greater or less distance. All plants differ from each other in the quantity, efficacy, and nature of this principle. Some contain it in great abundance, and are only in part deprived of it by drying, so that in these it appears to possess

possess a certain degree of fixity. Such, in general, are the odoriferous woods, and all the dry and ligneous parts of strong-smelling vegetables. In others, this principle is so volatile and transient, that though they have much smell, the spiritus rector can scarcely be retained, even with the greatest difficulty. Lastly, there are plants, which have a smell scarcely sensible; these are called inodorous, and their spiritus rector has been distinguished by the appellation herbaceous.

The slightest heat is sufficient to disengage the spiritus rector of plants. To obtain this principle, the plant must be distilled in a water-bath, and the vapours received in a head, which being kept cool, may condense them, and cause them to pass into the receiver in a liquid form. This product is a limpid water, charged with the principle of smell, and is called the essential, or distilled water of the plant. The odorous principle is more volatile than the fluid which holds it in solution. Heat drives off the spiritus rector, and the liquid becomes, of course, deprived of its peculiar smell; exposure to air produces the same effect, very light mucilaginous flocks being deposited, and the smell of the fluid being changed to that of mouldiness.

The principle of smell unites with the oily juices, and even seems to be one of the component parts of essential oils; for, 1. They



always abound with it. 2. Plants which have a permanent smell, constantly afford more essential oil than those whose principle of smell is very volatile, and which often afford no essential oil, as is the case with liliaceous plants. To retain the spiritus rector of these last, as the lilly, the jessamine, the tuberose, it is necessary to combine them with fat oil. These flowers are placed in a cucurbit of tin, together with cotton soaked in the oil of ben: the flowers and the cotton are disposed stratum super stratum; and the cucurbit being closed, a gentle heat is applied. The spiritus rector is disengaged, and combining with the oil, becomes durably fixed. 3. Plants which have no smell, do not afford the smallest quantity of essential oil. 4. Vegetables, whose spiritus rector has been extracted by distillation in the water-bath, no longer afford essential oil, or at least they do not, unless the distillation has been so managed, that they still retain part of their smell; in this case, they may afford a very small quantity. 5. An essential oil, which has lost its smell, resumes it very readily, with all its properties, when re-distilled from a fresh plant, of the same kind as that from which it was originally extracted.

The action of saline substances on the spiritus rector has not yet been examined.

The nature of this principle is not identical,

tical, but it seems to differ, according to the genera of the plants from which it is obtained. Macquer is of the same opinion with Boerhaave, that it is in general composed of an inflammable and a saline substance; but he observes, that it sometimes participates more of the saline nature, and in other plants is more oily. The spiritus rector of cruciferous plants appeared to him to be saline; and he gives it the character of being penetrating, without affecting the nerves. That which, on the contrary, is insipid or strong, without a keen and penetrating smell, and affects the nerves in such a manner, as either to produce or mitigate those symptoms which depend on their irritation, as is the case with aromatic and narcotic plants, participate more of the nature of oils, according to that celebrated chemist. Several facts may be brought in support of this assertion. The fraxinella emits an odour that forms an inflammable atmosphere around the plant, which immediately takes fire on the approach of an ignited substance: the vapour then burns from the bottom to the top of the stem which supports the flowers. The spiritus rector of fraxinella appears, therefore, to be of an oily nature. Venel, a chemist at Montpellier, and disciple of Rouelle, obtained an acid spiritus rector from savory (marum) by a gentle heat; and Roux, professor of chemistry in the schools

of medicine, who examined this product, discovered, that it does not redden blue vegetable colours, but that it saturates alkalis. Chemists are not agreed concerning the nature of the spiritus rector of cruciferous plants. Some think that it is acid, and others imagine it to be alkaline. From the experiments of Messrs. Deyeux and Baumé, it appears, that sulphur is found combined with the odorous principle of antiscorbutic plants; and that this combustible substance, in the state of an elastic fluid, constitutes the spiritus rector of cruciferous plants.

Two important considerations remain to be offered concerning the spiritus rector. The first is, that this principle, according to the very probable conjecture of Macquer, is probably a gas of a peculiar nature. Its invisibility and volatility, the manner in which it is expanded and dispersed in the atmosphere, together with certain experiments made by Dr. Ingen-housz on the noxious gas afforded by flowers, render this opinion very probable. It only remains, therefore, to make the proper experimental inquiries on this subject, which it must be confessed require the greatest care and accuracy, but at the same time promise to reward the inquirer with discoveries of the most important kind. Boyle has already opened an immense field, and his labours have been continued with the greatest suc-  
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cess by Lorry. This philosopher has attended to the alterations which arise from the mixture of odours, and the changes they undergo by fermentation, by the action of fire, of air, or of different menstrua. We cannot, without departing too far from our original plan, enter into any detail of his experiments, and shall therefore only exhibit his primitive division of odours. Lorry divides these bodies into five classes, to which all other odours may be referred; namely, camphorated, etherial, poisonous or narcotic, acid, and alkali. This physician, explaining the basis of his division, established on the effects of odours on the sense of smelling, and the nerves in general, affirms, that he does not propose to inquire into their chemical nature; but it is most probable, as he himself thinks, that the chemical properties of each class resemble each other, as well as those properties they exhibit in relation to the animal economy.

The second consideration, with which we shall terminate our history of the principle of smell, is, that though the plants called inodorous are considered as not possessing it, it is nevertheless well ascertained, that by the lowest heat of a water-bath, these also afford a fluid, whose smell, though feeble, is sufficient to discover the plant from which it was distilled. I can assert, from many experiments, that plants, reckoned most

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inodorous.



inodorous, afford, by the water-bath, a distilled water, which emits their proper odour, in such a manner as to distinguish them perfectly from each other. These waters are quickly decomposed, losing their faint characteristic smells, and becoming changed by fermentation, which discovers acid or alkaline characters, according to the nature of the substance.

The art of the perfumer consists in extracting the odorous principles of vegetables, and in preserving or fixing them in different substances. Most of the processes of this art are intirely chemical.

Distilled waters are much used in the art of medicine; they possess different virtues, according to their respective nature. Those only are used which are distilled by a naked fire, with the addition of water, as is done in the extraction of essential oils. We may observe, that this manipulation is advisable in making aromatic essential waters, but is defective with respect to such plants as are commonly called inodorous. We are of opinion, that it is indispensably necessary to distil them with the water-bath; and as this precaution is not usually taken, they have commonly an empyreumatic smell, instead of that of the plant. If the virtue of these waters reside only in their spiritus rector, feeble as it may be, it is certain, that the usual method of preparing them deprives them

them of all the properties they ought to have.

We must likewise add, that the distilled waters of plants, prepared in pharmacy, are not the pure spiritus rector, in the sense Boerhaave uses the word, but that the spiritus rector is diluted with a large quantity of water, which comes over in the distillation,

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## C H A P. XI.

Of Inflammable Resinous Juices in general,  
and of Natural Balsams in particular.

**T**HE name of resin is given to a dry, inflammable substance, not miscible with water, soluble in oils and spirits of wine, and which flows in a liquid state from the trees that produce them. These substances are oils, become concrete by being dried in the air. The difference between balsams and resins is not well settled. Some give the name of balsam to fluid inflammable substances, though there are likewise dry balsams. Others call the most odorous inflammable substances by this name. Bucquet has thrown considerable light on this subject, by confining the name of balsams to such combustible matters

matters as communicate a sweet taste to water, and more especially contain odorant and concrete acids, which may be obtained by sublimation or decoction in water.

The principal species of balsams may be reduced to the three following :

1. Benzoin ; this is distinguished into two species, the benzoe amygdaloides, formed of white tears, resembling almonds, united by a brown matter : common benzoin is brown, and without tears ; it emits a very agreeable smell, when fused or touched with a hot needle. The tree which affords it is not known ; but we receive this balsam from the kingdom of Siam, and the island of Sumatra. It affords very little essential oil, on account of its solidity. Boiling water extracts an acid salt, in the form of needles, of a strong smell, which crystallizes by cooling. It is likewise obtained by sublimation, and is then called flowers of benzoin. This operation is made in two glazed earthen pots, placed one above the other, and closed at the place of junction with paper. The sublimation must be performed with a gentle heat, otherwise the salt will be brown. The paper cone, formerly used as a subliming chimney, instead of the upper pot, causes the loss of a great part of the flowers. The smell of this salt is strong, and it produces a cough when inhaled. Its taste is acid ; it reddens syrup of violets, and effervesces with  
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the cretaceous alkalis. Benzoin, distilled in a retort, affords a very acid phlegm, a concrete and brown salt of the same nature, with a brown and thick oil. The residual coal contains fixed alkali.

Bergman and Scheele began the examination of the properties and elective attractions of the acid of benzoin; but their experiments are not sufficiently numerous to afford any very extended knowledge of this acid and its properties.

Benzoin dissolves in spirit of wine; and its tincture, precipitated by water, affords the lac virginale. The salt of Benjamin is used as a good incisive remedy in pituitous disorders of the lungs and veins. Its oil is discussive, and is externally applied in paralytic disorders, &c.

2. Balsam of Tolu, Peru, or Carthagena. It is imported either in cocoa nut shells, or in yellowish tears, or in a fluid state. It flows from the *Toluifera*, placed by Linnæus in the decandria monogynia. It may be extracted from the shells, by steeping them in boiling water, which renders it fluid. It comes from South America, in the tract between Carthagena and Honduras. It affords the same products as benzoin, and more particularly the concrete acid. It is made into a syrup, and is used in disorders of the lungs.

The acid of balsam of Tolu has not been  
suffi-



sufficiently examined to determine whether it essentially differs from that of benzoin.

3. Storax calamita is in tears, either red and clean, or brown and unctuous. Its smell is very strong. It flows from the oriental liquid amber, a plant very little known. Newman analyzed the storax calamita, and obtained a very small quantity of essential oil, a concrete acid salt, and a thick oil. This balsam is applied to the same uses as benzoin, and is more particularly consumed by perfumers. It was formerly imported inclosed in reeds, or canes; we now receive it in the form of loaves, or irregular masses, of a reddish brown colour, mixed with some tears of a lighter colour, and of a very agreeable smell.

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## C H A P. XII.

### Concerning Resins.

**R**ESINS differ from balsams in their smell, which is less agreeable, and especially in their containing no concrete acid salt; the principal species are the following:

1. Balsam

1. Balsam of Mecca, of Judea, of Egypt, of Grand Cairo. It is liquid, white, bitter, and of a very strong smell, resembling that of lemons. It flows from a tree called *amyris opobalsamum*, placed by Linnæus in the octandria monogynia, and discovered in Arabia Felix by Mr. Forskahl. This liquid resin affords much essential oil, by distillation; it is incorporated with sugar, yolk of eggs, &c. and used as a vulnerary.

2. The balsam of copaiba, of a brown or yellow colour, which flows from the tree called *copaiba*, or *copaifera*, of Linnæus, and placed by that botanist in the decandria monogynia. The common sort, as well as that of the balsam of Tolu, is a mixture of the true balsam of copaiba and turpentine, according to Cartheuser. It is used in ulcers of the lungs and bladder, like the foregoing.

3. Chio turpentine is afforded by the turpentine tree, which bears pistachio nuts. It is of a white, or blueish yellow colour. By the water-bath, it affords a very fluid essential oil; but the oil obtained by a naked fire is less fluid. The turpentine, after this process, is yellower; if the distillation be made with water, it is white and silky, and is called boiled turpentine. This is rarely met with, and is now no longer used.

4. Venice turpentine is commonly used in medicine, either in its natural state, or combined with fixed alkali. This combination

nation is called Starkey's soap. The dispensatory of Paris directs four ounces of essential oil of turpentine to be poured on half a pound of nitre, fixed by tartar, before it is become cold. The mixture is to be agitated with a spatula of ivory, and the vessel kept covered with a paper, more oil being from time to time added, till the whole forms a white mass. As this process requires several months time to complete it, chemists have endeavoured to discover more expeditious methods of performing it. Rouelle, by triturating the alkali, drop by drop with the soap, and adding a small quantity of water towards the end, prepared a considerable mass of this soap in the space of three hours. M. Baumé directs one part of alkali of tartar, heated till it fuses, to be ground on a levigating stone, three or four times its weight of essential oil of turpentine being gradually added. When the mixture has acquired the consistence of a soft opiate, he exposes it in a moist place, in a glass vessel covered with paper. In fifteen days, the deliquescent alkali forms a stratum of liquor at the bottom of a vessel, the soap is in the middle, and a portion of the oil, of a red colour, floats above. M. Baumé thinks, that the alkali unites only with that portion of the oil which is in the resinous state. M. Le Gendre carries this notion farther, and proposes to saturate a cold solution of fixed  
alkali

alkali with oil of turpentine become thick, or turpentine itself. This soap has a certain degree of solidity, which gradually becomes more considerable; it affords crystals, which have been considered as a combination of the acid of the oil with the vegetable fixed alkali; but which, according to the academicians of Dijon, consist of the vegetable alkali, saturated with the cretaceous acid. As this soap is very difficult to make, and subject to change, Macquer thinks, that when an union of the properties of essential oils with those of soap, is desired, it is more advisable to incorporate with the white medicinal soap, a few drops of that essential oil, whose qualities may answer the intended purpose. Pure volatile alkali, triturated with turpentine, forms a saponaceous solid compound, soluble in water, to which it gives a milky appearance.

5. The resin of fir is called Strasburg turpentine; it is collected by piercing the vesicles of the bark of fir trees, which grow plentifully in the mountains of Switzerland.

6. Pitch is the juice of a kind of fir, called *abies picea*; it is extracted by incisions made in the bark of the tree. It is melted by a gentle fire, and strained through sacks; after which it is received in barrels. Burgundy pitch is white, but the mixture of coaly matter gives the black colour. When pitch is long kept in fusion with vinegar,



negar, it dries, becomes brown, and forms colophony. The dregs of pitch are burned in a fire-place, whose chimney leads into a small chamber, terminated by a cone made of cloth: in this last, the smoke condenses, and forms the fine soot, called lamp-black.

7. Galipot, or resin of the pine. Holes are bored in the lower part of this tree, through which the resin flows into troughs. Other incisions are made higher up, when the former afford no more. When emitted in the fluid state, it is called galipot; the portion which dries on the tree, in yellowish masses, is called barras. These juices are melted, and when thickened by heat, are filtered through straw mats, and poured into moulds in sand. They then form masses, called arcancon, or bray-sec. If water be added, the matter becomes white, and forms resin, or pitch resin. Galipot is distilled in the large way in the provinces of France, and affords an oil, called huile-de-raze, or caulking pitch. The tar, which is the empyreumatic oil of this substance, is prepared with the branches and roots of the pine. The wood of this tree is laid in heaps, covered with turf, and set on fire. The oil, disengaged by heat, not being capable of escaping through the turf, is precipitated into a shallow tub, by means of a channel, and is collected for sale by the name of tar.

8. Tacamahaca, gum elemi, gum animæ,  
are

are very little used : the tree that affords the fruit is not known. The gum elemi is obtained from a species of amiris ; the oriental gum anime, or copal, whose origin is unknown, and the oxidental gum anime, or courbaril, which flows from the hymenea, a tree growing in South America, are used to make varnishes.

9. Mastic is in white farinaceous tears, of a weak smell ; it flows from the turpentine tree, and the mastic tree. It is used as an astringent and aromatic, and enters into the composition of drying varnishes.

10. Gum sandarac is in white tears, more transparent than mastic. It is obtained from the juniper, between the bark and the wood. It is used to prevent the sinking of ink into paper, whose external coating of size has been scraped off in making erasures.

11. The resin of guaicum, which is greenish, is used as a remedy for the gout. It is obtained from the guaicum tree, by incision.

12. The labdanum, or resin of a species of cistus in Candia, is blackish. The country people collect it by means of a staff, at the end of which are fastened many leather thongs, which they gently strike on the trees. They form it into cylindrical pieces, which are called labdanum in tortis. It is greatly adulterated by the addition of black sand, and is used as an astringent.

13. Dragons blood is a red juice, obtained from the *dracæna draco*, and several other trees of the same kind. It comes to us in flat or round pieces, or in small balls, wrapped up in leaves. It is used in medicine as an astringent.

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### C H A P. XIII.

#### Gum Refins.

**G**UM refins are juices mixed with resin, and an extractive matter, which has been taken for a gummy substance. They never flow naturally from plants, but are extracted by incision, in the form of emulsive white, yellow, or red fluids, which dry more or less quickly. Water, spirit of wine, wine, or vinegar, dissolve them only in part. They differ in the proportion of resin and extract, and their analysis affords various results: the species most necessary to be known are the following.

1. *Olibanum* consists of yellow transparent tears, of a very disagreeable smell. The tree which affords it is not known. By distillation, a small quantity of essential oil, together with an acid spirit, are obtained, and the coaly residue, arising from the extractive

tractive part; is very considerable. It is used in medicine for fumigations.

2. Galbanum is a fat juice, of a brown yellow colour, and nauseous smell. In Syria, Arabia, and at the Cape of Good Hope, it flows from incisions made in a ferulaceous plant, named *bubon galbanum* by Linnæus. Distilled with a naked fire, it affords a blue essential oil, which afterwards becomes red; and also an acid spirit, with a ponderous empyreumatic oil. It is a very good discutient remedy, and is powerfully antispasmodic.

3. Scammony is of a blackish grey colour, a strong and disagreeable smell, a bitter and very acrid taste. The Aleppo scammony is distinguished by its greater purity from that of Smyrna, which is ponderous, black, and mixed with foreign substances. It is extracted from the *convolvulus scammonia* of Linnæus. The root of this plant, cut in pieces and pressed, affords a white juice, which is black when dried. The different specimens of scammony contain various proportions of extract and resin, and its medical effects differ accordingly. It is prescribed as a purge, in the dose of from 4 to 12 grains. Mixed with a sweet extract, such as that of liquorice, it forms the common diagredium; the juice of quinces is likewise used for this purpose. The common mode of administering it, is after previous trituration with sugar and sweet almonds.



4. Gum gutta is yellow, reddish, without smell, and of a very acrid and corrosive taste. It comes from Siam, China, and the island of Ceylon. It is extracted from a large tree, not much known, called by the natives, coddam pulli. It contains much resin, which renders it strongly purgative, in a dose of from 4 to 6 grains. It ought not to be internally used, but with the greatest caution.

5. Euphorbium is in yellow tears, which have the appearance of being worm-eaten; it has no smell. It flows from incisions made in the euphorbium, which grows in Ethiopia, Lybia, and Mauritania. It contains a very acrid resin, and is so strongly purgative, that it is reckoned among poisons. It is not used, unless externally, in caries.

6. Assafœtida is sometimes in yellowish tears, but most commonly in loaves, formed of a number of pieces, agglutinated together. It has a very fetid smell of garlic, with a bitter and nauseous taste. It is extracted from the root of a species of ferula, which grows in the province of Chorasan, and is called assafœtida by Linnæus. The root of this plant is fleshy and succulent. By expression, it affords a white juice, of an abominable smell, which the Indians use as seasoning for food, under the name of food of the gods. It is internally used as a powerful

ful antispasmodic, and is applied externally as a discutient remedy.

7. Aloes is a juice of a deep red, or brown, and very bitter. It is distinguished into three species; succotrine aloes, hepatic aloes, and cabaline aloes: these differ only in their respective degrees of purity, the first being the best. A. De Jussieu saw the preparation of the different kinds of aloes, from the leaf of the common aloë plant. Deep incisions are made, from which the juice flows; this is decanted from its fecula, and thickened by the sun's heat, in which state it is packed in leather bags, under the denomination of succotrine aloes. The juice obtained, by pressure, from the leaves, after it is purified by repose, and dried, is the hepatic aloes. The same leaves, by stronger pressure, afford a portion of juice, which, mixed with the dregs of the two foregoing, constitutes the hepatic aloes. The first sort contains a much less quantity of resin than the two last, which are more strongly purgative. It is used in medicine as a drastic purge, and is acknowledged to possess the property of exciting the menstrual flux in women, or the hemorrhoids in men. It is much esteemed as a good hydragogue.

8. Myrrh is brought to us in the form of reddish brilliant tears, of a strong and rather agreeable smell, bitter taste, and exhibiting white lines, of the form of a nail, in their fracture.

fracture. Some of these tears are intirely gummy, and insipid. Myrrh comes from Egypt, and especially from Arabia, in the country of the Troglodites. The plant from which it is extracted is not known. It contains much more extract than resin. It is used as an excellent stomachic, antispasmodic, and cordial remedy. Cartheuser advises literary men, whose stomachs are delicate, to chew this, and swallow it with the saliva. It is used in surgery, either in powder, or dissolved in spirit of wine, to cleanse foul ulcers, and to stop the progress of caries.

9. Gum ammoniac sometimes has the form of tears, white within, and yellow without, and is sometimes in masses resembling benzoin. They are easily distinguished by their white colour and fetid smell. It is suspected, from the admixture of seeds it contains, that this gum resin, which comes from Africa, is extracted from an umbelliferous plant. The solubility of this substance in water, and in spirit of wine, and more particularly its inflammability, are properties in which it resembles the resinous extractive matters of Rouelle.

Gum ammoniac is medicinally used as a discussive remedy in obstinate obstructions; it is given in doses of a few grains, in pills or emulsions, and likewise enters into the composition of many discussive and resolvent plasters.

10. The

10. The elastic gum, or caout-chouc, is a vegetable substance, whose nature cannot easily be determined; for though, in its combustible property, which is applied to the purpose of illumination in America, it seems to resemble resins, yet its elasticity, softness, and insolubility in the menstrua which dissolve these last, are characters which shew that it greatly differs from them.

The tree which affords this substance grows in several parts of America. Horizontal incisions are made quite through the bark; a white and fluid juice issues forth, which is applied, in successive coats, on clay moulds, and dried by the sun's heat. Various sketches of designs are made on the surface with an iron tool. It is then exposed to the smoke; and when perfectly dried, the clay is crushed and taken out. The bottles, and various utensils of elastic gum, which are imported into Europe, are made in this manner.

Vessels of elastic gum may be used to contain water, and various fluids which do not corrode its substance. If it be cut into pieces, and the newly-cut edges applied to each other, they adhere together with considerable force.

Elastic gum, set on fire, softens, swells up, emits a fetid smell, and shrinks as it burns.

It is not soluble in water; and the action



of saline matters on this substance is not known. Macquer, who attempted to dissolve it in different menstrua, clearly ascertained, that it was not at all acted on by spirit of wine, as Messrs. De la Condamine and Fresneau had before asserted, in the Memoirs of the Academy for 1751, but that oils dissolve it, by the assistance of heat. Nevertheless, as his intention was to liquefy, or dissolve it in such a manner, as that it might be used, and resume all its properties, by the evaporation of the solvent, it became necessary for him to use a more volatile menstruum than oils, which remain combined with the gum, and deprive it of its elasticity. Highly rectified ether, which readily dissolves this substance, and may be quickly evaporated, answers the purpose perfectly well. (See the Memoirs of the Academy for the year 1768.) And though this fluid is very expensive, he thinks it may be advantageously used in making certain utensils, such as catheters, by successively applying this solution on a mould of wax, till it is of the required thickness. When it is dry, the wax may be easily separated, by immersion in boiling water. The softness and elasticity of this instrument, renders it extremely useful for such as are under the necessity of continually using it.

Such was the state of our knowledge, respecting the elastic gum, when, in the month  
of

of April, 1781, Mr. Berniard, well known by the accuracy of his experiments, inserted, in the *Journal de Physique*, an excellent memoir concerning this singular substance. This chemist concluded, from his experiments, that the elastic gum is a peculiar kind of fat oil, coloured by matter which is soluble in spirit of wine, and blackened by the smoke, to which each coating is exposed to dry. Water does not at all change it; spirit of wine deprives it of its colour, by boiling. The caustic fixed alkali does not act upon it. Oil of vitriol reduces it to the state of coal, itself becoming black, and assuming the smell and volatility of the sulphureous acid. The common nitrous acid acts in the same manner on this substance as on cork, changing its colour to a yellow. Spirit of nitre very quickly destroys it, but the muriatic acid does not affect it in the least. Rectified vitriolic ether did not dissolve it. This fact, as the author observes, must appear singular, to all who are acquainted with the exactness and the veracity of Macquer. Nitrous ether dissolves it, and becomes yellow, affording, by evaporation, a transparent friable substance, which is soluble in spirit of wine, and is in fact a true resin, formed, according to the author, by the action of the nitrous acid on the elastic gum. The essential oil of lavender, and likewise those of aspic and of turnsole, dissolved

solved it by the help of a slight heat; but they formed gluey fluids, which daubed the hands, and consequently were not applicable to any use. A solution of elastic gum, mixed with spirit of wine, deposited white flocks, insoluble in hot water, at the top of which they floated, and became white and solid, like wax, by cooling: it appeared to be a true congealable fat oil. Oil of camphor dissolved elastic gum, by simple maceration. By evaporating this solution, the camphor was driven off, and an amber-coloured matter, of a firm consistence, scarcely adhesive, remained in the capsule, and was found to be easily soluble in spirit of wine. Fat oils, boiled on elastic gum, dissolve it, as does likewise wax. This substance does not melt by the heat of boiling water; but when exposed to a greater heat, in a silver spoon, it is converted into a black thick oil, emits white vapours, and remains fat and adhesive, though exposed to the air for several months, and does not recover the dryness and elasticity in which its chief utility consists. Lastly, Mr. Berniard concluded his inquiries, by analysing elastic gum with a naked fire. One ounce afforded a very small quantity of phlegm; an oil, at first light and clear, but afterwards thick; and coloured and volatile alkali, in a quantity which he has not ascertained. The coaly residue was similar to that of resins, and

and weighed 12 grains. This chemist attributes the volatile alkali to the foot with which the elastic gum is coloured.

We must observe, that this analysis does not accurately ascertain the nature of elastic gum, because the action of acids on this substance does not resemble that which they exhibit with fat oils, and which is much more rapid; because caustic alkalis do not convert it into soap; because it does not melt, but by a degree of heat much greater than is necessary to melt the most solid fat oils; because no fat oil becomes dry and elastic, &c. &c. The author, besides, in his fifteenth experiment, affirms, that this gum is composed of two distinct substances, which he does not exhibit; and he concludes, by considering it as the product of art. From all these reflections, and many others which may be added, concerning the experiments of Mr. Berniard, valuable as they are, we think, with him, that much remains to be done, to ascertain the properties of this substance, and to enable us to decide respecting its nature.



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C H A P. XIV.

## Of the Pure Fecula of Vegetables.

THE juices of vegetables, elaborated in their vessels, become thick, and are gradually deposited on the surface of the fibres, which are by that means supported and augmented, or become accumulated, in a more or less solid form, in the organs of the plant. After having treated of the fluid parts of these organized substances, it is necessary to examine the substance of which their solids are composed. We are far from possessing an accurate knowledge of all the solid substances contained in vegetables; but it appears, that when treated by the processes we are about to describe, they are reducible into a dry, pulverulent, insipid, white, grey, or variously coloured substance, insoluble in cold water, and of an earthy appearance, called fecula.

To obtain this substance, a root, stem, leaf, or seed, is reduced to a pulp, by pounding. Succulent vegetables may be treated in this manner, without the addition of water; but in general water is added, to facilitate the separation of the fibres, and to  
carry

carry off the divided and pulverized parts. The pulpy matter, by strong pressure, affords a turbid, white, or coloured fluid, which after some time deposits, by standing, a substance partly fibrous, and sometimes pulverulent, which is the true fecula of vegetables. Some parts of vegetables appear to be intirely composed of this matter; such as the seeds of gramineous and leguminous vegetables, tuberous roots, &c. These parts in general afford the finest and most abundant fecula. As to the tender stems and leaves of vegetables, their more fibrous texture affords only a coarse-coloured filamentous deposition, distinguished by the name of coarse fecula. If these be well dried, pulverized and washed, the water carries off a much finer fecula, perfectly similar to that of the tuberous roots and gramineous seeds. The chemist, therefore, makes no other distinction between these two kinds of fecula, than that the first is obtained from a less fibrous part, consisting, as it were, of cells, in which nature has deposited dry or farinaceous mucilage; while the second, being of a more fibrous texture, requires its organization to be destroyed by a more artificial process.

All the vegetable parts of solids, strictly speaking, afford a kind of fecula; but we shall here more particularly speak of such as are prepared by art for food or medicine.

The

The fecula of bryony, potatoe, cassava, fago, falop, and starch, are those we shall particularly attend to.

1. To prepare the fecula of bryony, the first roots are deprived of their bark, rasped in pieces, and submitted to the press. The juice is white, and deposits a very fine fecula, from which, at the end of twenty-four hours, the liquid is decanted, and it is dried. As this fecula contains a certain quantity of extract, left by the juice, it is very acrid, and purges violently: by washing, it becomes finer, and whiter, but at the same time loses its purgative virtue. This method of preparing the fecula of bryony affords but a very small quantity, but a much greater may be obtained, by moistening, with water, the mass remaining in the press, straining this water through a hair sieve, to separate the grosser fibres, and leaving it at rest, and to deposit its fecula, at which time the water is to be decanted off, and the powder dried. This last fecula is not purgative, like the former, because it has been deprived of its extractive matter by the water. Mr. Baumé has observed, that the fecula of bryony is absolutely the same as starch, and may be made into hair powder, to the great saving of corn. The fecula of the roots of arum, and cornflag, are prepared in the same way for medical uses.

2. Potatoes are among the most useful  
alimentary

alimentary substances, with respect to their abundance and fertility. They afford a large quantity of very fine white fecula, which, when boiled, is an excellent food. It is obtained by scraping the potatoes into a sieve, and pouring thereon a large quantity of water. The fluid carries off the finest and most divided part of the fecula, which subsides by standing. The water is decanted off, and the fecula, dried by a gentle heat, has the form of a very fine white powder. Mills, consisting of a kind of rasps, turning on cylinders, have been contrived, and are used to great advantage in preparing this fecula.

3. The Americans extract, from the root of a very acrid plant, called manioc, a mild nourishing fecula, which they call cassava. They strip the root, rasp it, and put it into a sack of rushes, made in the form of a cone, and of a very open texture, which they suspend to a staff, placed across two upright posts. At the lower extremity of this sack, they hang a heavy vessel, which by its weight presses the root, and receives the juice which flows out, and is a most acrid and dangerous poison. When the fecula is well pressed, and deprived of all its juice, it is dried in the smoke, sifted, and then forms cassava. This farina is spread on a hot plate of iron, and turned till both its surfaces acquire a reddish yellow colour, which denotes that it is sufficiently baked. In this state it is called



called cassava bread. When the farina is heated in a vessel, and agitated from time to time, it takes the form of grains, called couac. A very fine and mild fecula, called mouffache, falls to the bottom of the expressed juice, and is used for pastry.

4. Sago is a dry fecula, reduced into grains by the action of fire, and comes to us from the islands of Molucca, Java, and the Phillipines. It is obtained from a kind of palm, called landan, in the Moluccas. The trunk of this tree contains a sweet pith, which the inhabitants take out after having split the wood; they then bruise it, and put it into a kind of cone, or funnel, made of bark, and pour on a large quantity of water. This fluid carries with it, through the sieve, the finest and whitest part of the pith, the fibrous part remaining behind. The water is received into pots, and gradually deposits the fecula. The clear water is then decanted, and the deposited matter is passed through perforated plates, which give it the form of small grains. The red colour on their surface rises from the action of fire, used in the drying. These grains, or sago, become soft and transparent in boiling water, and form, with milk or soup, a light and agreeable liquid, which is strongly recommended in phthical disorders.

5. Salep, salop, salab, &c. is the root of a species of orchis, prepared by the orientals.

tals. They select the finest bulbs of this plant, which they peel, and boil, after previously soaking them in cold water. They are then strung, and dried in the air. M. Jean Moulton describes another process for preparing salop, which may be used with every kind of orchis. The roots, either dry or under water, are rubbed with a brush, to take off the external pellicle; after which, by drying in an oven, they become very hard and transparent. These are very easily reduced into powder, which, with hot water, forms a nourishing jelly, much praised by Geoffroy, in all disorders arising from an acrid state of the lymph, and especially in consumptions, and the bilious dysentery.

## C H A P. XV.

Concerning the Farina, and Starch of Corn.

**S**TARCH, properly speaking, is a fecula absolutely similar to the foregoing; but as the farina of corn, of which it is a constituent part, is one of the most important substances that come under the examination of the chemist, we shall treat more fully on this than on the other fecula.

The substance called flour, is in general  
 VOL. IV. G dry,

dry, friable, insipid, capable of acquiring taste and digestibility, by the action of fire, and composed of several substances easily separable from each other. It exists in the seeds of gramineous plants, more especially wheat, rye, barley, oats, rice, buckwheat, &c. Leguminous plants likewise appear to contain a compound analogous to flour; but the flour of wheat only can be said truly to possess the requisite properties, because it is the only farina in which the different substances are duly proportioned to each other. Though the economical use of the flour of wheat, as the principal article of nourishment, has been established from time immemorial, it is but lately that chemists have begun to examine it. Messrs. Beccarri, an Italian physician, and Kessel Meyer, in Germany, are the first chemists who endeavoured to separate the different substances contained in flour. Messrs. Rouelle, Spielman, Malouin, Parmentier, Poulletier de la Salle, and Macquer, continued and carried the experiments of these philosophers much farther. Mr. Parmentier, especially, has prosecuted this inquiry with uncommon zeal and activity. His researches into the nature of alimentary substances, the component parts of flour, the different species of fecula, and on all nutritive vegetables in general, are, without doubt, the most complete and exact of any that have been made in this way.

Water

Water is an agent of the greatest utility, and least capable of altering the several matters it takes up, or separates, in the order of their solubility. This fluid is used, with the greatest success, to obtain the different substances of which wheat flour is composed. To perform this true analysis, a paste is made with flour and water, and kneaded in a vessel of water, underneath a stream from a cock; the water carries off a very fine white powder, and the kneading must be continued till this fluid passes off clear. The flour is then found to be separated into three substances; a greyish and elastic matter remaining in the hand, which has been called the glutinous, or vegeto-animal part, on account of its properties; a white powder, deposited by the water, which is the fecula, or starch; and a substance, held in solution by the water, which appears to be a kind of mucilaginous extract. We shall examine the properties of each of these three substances in order.

§ I. Concerning the Glutinous Part of Wheat.

The glutinous part, is a tenacious, ductile, elastic matter, of a whitish grey colour. When drawn out, it extends about twenty times its length before it breaks, and appears as if composed of fibres, or filaments, placed



beside each other, according to the direction in which it has been drawn. If the force ceases, it resumes its original form by its elasticity. By drawing it out, in different directions, it may be made so thin, that its polished surface resembles the texture of animal membranes. In this state it adheres strongly to dry bodies, and forms a very tenacious glue, which was used by some persons to join broken china, long before chemists found the means of obtaining it in large quantities. Mr. Beccari has observed, that the proportion of glutinous matter is from a fifth, to a third, and more, in flour of the best quality; he has likewise observed, that this quantity varies in different seasons, and according to the nature of the corn.

The smell of the glutinous matter is faint, and resembles that of mucilage; exposed to a fire capable of suddenly drying it, it swells up prodigiously. In a dry air, or mild heat, it dries very well. It is then semi-transparent, and hard, like glue, and snaps short like that substance.

If in this state it be placed on burning coals, or applied to the flame of a candle, it exhibits all the characters of an animal substance; it decrepitates, swells, liquifies, curls up, and burns like a feather, or a piece of horn, emitting, at the same time, a strong and fetid smell. By distillation, it affords, like animal substances, alkaline spirit, concrete

crete volatile alkali, or ammoniacal chalk, and an empyreumatic oil. Its coal is very difficultly incinerated, and does not contain fixed alkali.

Fresh gluten, exposed to a hot and dry air, becomes changed, and putrifies absolutely in the same manner as animal substances. When it retains a small quantity of starch, this last passing to the acid fermentation retards and modifies the putrid fermentation, and converts the substance into a state nearly similar to that of cheese. Rouelle the younger prepared a cheese with the gluten, which singularly resembled in its smell and taste, that of Gruyeres, or of Holland.

Water does not at all dissolve this glutinous matter. By boiling in this fluid it becomes solid, loses its extensibility and adhesive quality, but does not acquire either taste or solubility in the saliva. Nevertheless, we must observe, that the gluten owes its elasticity and solidity to the water which formed the paste. In fact, this vegeto-animal portion, though capable of becoming solid and elastic, is pulverulent, and without cohesion in the flour; but as soon as water is added, its particles absorb the fluid, and adhere together, forming the elastic substance called gluten. Water, therefore, contributes greatly to the formation of this substance, and it

may perhaps be considered as a compound, saturated with, and incapable of absorbing a larger quantity of water. This is so true, that it absolutely loses its adhesion and elastic properties by drying.

Most saline substances act more or less efficaciously on the gluten. The caustic fixed alkalis in the fluid state dissolve it by boiling. This solution is turbid, and deposits, by the addition of acids, a gluten which is not elastic.

The mineral acids dissolve the gluten. The nitrous acid dissolves it with great activity, and Mr. Berthollet has observed, that this acid disengages mephitic, as it does from animal substances. When this elastic fluid has been emitted, the solution affords a large quantity of nitrous gas, and becomes of a yellow colour. By evaporation it affords crystals of the acid of sugar. The vitriolic and marine acids form brown or violet solutions of this substance, from which a kind of oily matter separates; the gluten being truly decomposed. Mr. Poulletier, who has made many experiments on this substance, has discovered, that ammoniacal salts may be obtained from these combinations, dissolved in water, or spirit of wine, and evaporated in the open air.

From these facts, it follows, that this substance is totally different from all those hitherto known in vegetables, and that in  
many

many of its characters it resembles the fibrous part of the blood. It is to this gluten that wheat flour owes its property of forming a very adhesive paste with water, and the facility with which it rises in leaven. The gluten does not appear to exist, at least in any considerable quantity, in other farina, such as that of rye, barley, buckwheat, rice, &c. ; all which form solid, opaque pastes, scarcely ductile, easily broken, and which do not ferment when exposed to the temperature by which that process is effected in wheat paste. The presence of the gluten appears therefore to be necessary for the production of good bread.

Mr. Berthollet thinks that this glutinous substance contains phosphoric salt, like animal matters, and that this is the cause of the difficulty with which its charcoal is incinerated. Rouelle the younger found a glutinous substance analogous to that of wheat in the green fecula of plants, which afford volatile alkalis and empyreumatic oil, as does the vegeto-animal substance here treated of.

## § II. Concerning the Starch of Wheat.

Starch, or the amylaceous fecula, composes the greater part of flour ; it is the white substance which subsides from the water used in obtaining the pure gluten.



This substance is very fine, and soft to the touch; its taste is scarcely sensible. Its colour is of a grey and dirty white, when extracted by the process we have described; but the starch-makers render it extremely white by suffering it to remain in the water for a time, after it has become acid. It appears from the experiment of Mr. Poulletier, that the fermentation which takes place in this fluid, whitens and purifies the starch by attenuating, and even destroying the extractive mucilaginous substance with which it is vitiated at first. Starch, chemically considered, is a mucilage of a peculiar nature. This mucilage, which has been improperly considered as an earth by some chemists, differs greatly from the glutinous part. It burns without emitting an empyreumatic smell. By distillation with a naked fire, it affords an acid phlegm, of a brown colour, and a very thick empyreumatic oil towards the end. Its coal is easily reduced to ashes, which contain fixed alkali.

Starch is not soluble in cold water, but when boiled in water, it forms a kind of glue, that, when exposed to a moist air, gradually loses its consistence, ferments, becomes sour, and at last mouldy.

The nitrous acid produces the acid of sugar with this fecula, which is perfectly similar to those we have treated of in the foregoing chapter.

As

As starch forms the greatest part of flour, it cannot be doubted, but that it is the principal alimentary substance contained in flour, and in bread.

§ III. Concerning the Mucilaginous Extractive Part of Flour.

By evaporating the pure water with which the paste was washed, and from which starch had been deposited, Mr. Poulletier obtained a viscous gluey substance of a brown yellow colour, and slightly saccharine taste. This substance, denominated by its discoverer the mucofo-saccharine matter, exhibited all the phenomena of sugar in its combustion and distillation. It is this which excites the acid fermentation in the water that floats above the starch; for, as Macquer well observes, the latter is not at all soluble in cold water.

The mucofo-saccharine matter exists in a very small proportion in wheat corn, but may pethaps be more abundant in other kinds of flour.

It cannot be doubted, notwithstanding the small quantity of this substance contained in wheat corn, but that it is principally concerned in the fermentation by which paste is leavened. This intestine motion, so necessary in the making of good bread, is not yet well understood. It may perhaps consist

sist in the commencement of fermentation, which is putrid in the gluten, acid in the starch, and perhaps spiritous in the mucosofaccharine matter; and from these three incipient fermentations mutually impeding each other, the lighter compound, which by baking forms bread, may probably arise. At all events, it is certain, that the three substances we speak of are so combined and altered in bread, that they can no longer be separated. The action of heat is sufficient, without fermentation, to produce this intimate combination; for unleavened bread, according to Malouin and Poulletier, does not afford the glutinous matter.

From the foregoing facts we see, how greatly other kinds of flour differ from that of wheat, and still more those leguminous and farinaceous seeds, such as beans, pease, chefnuts, &c. are far from possessing the qualities necessary to make good bread,

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#### C H A P. XVI.

Concerning Vegetable Colouring Matters,  
and their Application to the Art of Dying.

**V**egetables contain colouring matters in all their organs. These parts differ greatly from each other; for a vegetable substance, which

which has no apparent colour, often assumes a very evident tinge, by peculiar menstruums. The art of dying, all the processes of which are absolutely chemical, is founded on the solubility of colouring matters in different menstrua, the method of applying them to substances proposed to be dyed, and of rendering them fixed. In treating of the properties of each colouring matter, we shall have occasion to speak of the principles of this important art, which is excellently treated of in the works of Hellot, Macquer, Le Pileur d'Apligny, Hecquet d'Orval, and the Abbé Mazeas.

The colouring matter of vegetables properly so called, is not yet well known. Rouelle supposed that the colouring matter, which is so abundant in the vegetable kingdom, was analogous to the gluten of flour; but it is certain, that this matter presents different chemical characters, according to the base with which it is united. When, therefore, it is said, that a colour is extractive, resinous, &c. the terms apply rather to the base, than to the colouring matter. The true colouring matter of vegetables used in the arts, is doubtless of a very subtle nature, and is perhaps as divisible as the principle of smell. It may even be supposed, that it consists only in a peculiar modification of the solid and liquid parts of vegetables. It is necessary to repeat in this place, that the colour  
of



of vegetables is for the most part produced by the contact of light; but the manner in which light produces this effect, is a problem not yet solved. However this may be, as it is impossible to separate the colouring matter intirely from the vegetable base it adheres to, these two substances are usually taken together for the colouring matter.

No chemist has more accurately distinguished the vegetable colouring matters, considered with respect to the art of dying, than Macquer; and his theory concerning the applying and fixing these colours to substances intended to be dyed, must be admitted as highly satisfactory. As it is our intention to connect this theory of dying with the history of the chemical properties of vegetable colouring matters, we shall consider them in the same point of view.

1. A great number of vegetable colouring matters, which are of an extractive or saponaceous nature, are readily dissolved in water. Bastard rocket, madder, logwood, redwood, and Brasil wood, afford yellow or red colours of this kind. It may be easily conceived that substances tinged with these matters, readily give out their colour to water; and it is therefore found necessary, in order to render them durable, to make use of some additional substance capable of decomposing and fixing them; as for example, crude tartar, alum, and other salts. These  
salts

salts are called corrosives. A disengaged acid would produce the same effects, but it would alter the colouring matter. The portion of superabundant acid of the alum unites with the alkali of the colouring sapo-naceous extract, and causes the resinous part, which is then insoluble in water, to be precipitated on the substance intended to be dyed. However, this colouring portion, rendered insoluble by the alum, or the corrosive, is of two kinds; the first is very solid, and resists the air, soaps, and all the liquors which dyers call proofs. This kind of colour is called a good or strong dye. The other is changed by the air, and especially by the action of the proof liquors: It is called a false dye. To discover the nature of these colours, and the duration of dyes in general, Mr. Berthollet proposes the use of the de-phlogisticated or aerated muriatic acid, which in a very short time, by its excess of the oxygenous principle, produces the same effect as the pure air of the atmosphere would effect in a much longer space of time. The quantity of acid required to discolour and intirely bleach any dyed stuff, as well as the time required for this purpose, may serve to determine the solidity and duration of colours.

It is observable that wool takes the dye better than any other substance; and that silk, cotton, and flax, in the order we have mentioned

tioned them, are dyed with more difficulty, and retain the colouring substance more weakly.

Writers on the art of dying, hold different opinions respecting the manner in which the colouring parts apply themselves to the substances exposed to their contact. Many have supposed that this application takes place only in proportion to the number and magnitude of the pores in the various substances; and that wool takes the dye better than silk or thread, because its pores are more open and numerous. But Macquer thinks, that the greater or less facility with which the colour is applied, depends on the respective nature of the colouring parts and the substance proposed to be dyed; and that the art of dying is truly an external tinge or painting, which succeeds and lasts by virtue of an affinity and intimate union between the colour and the dyed substance. This celebrated chemist adopted the opinion here recited, in consequence of the numerous experiments for which this art is greatly indebted to him.

2. Another kind of colouring matter seems to be composed of saponaceous extract and resin. Macquer calls them resino-terrestrial matters. When these matters are boiled in water, the resinous substance they contain melts, and is dispersed in the fluid by the assistance of heat, and by virtue of the dissolved saponaceous portion; but it precipitates in  
pro-

proportion as the decoction or bath becomes cold. Consequently, when wool, or any other substance is plunged in a decoction of this nature, the resin separates by cooling, and applies itself without any other preparation; and as it is not soluble in water, it forms a lasting dye. Colouring matters of this class are obtained from almost all astringent vegetables, such as the husks of nuts, roots of walnut-tree; or of dock, fumach, bark of alder, sandal-wood, &c. These colours are all yellow, and are called root colours by the dyers. They generally serve to form a very good ground, on which other more brilliant colours may be applied. It may be observed, that colouring ingredients, which require no preparation either in the bath, or in the stuff to be dyed, are more easily applied to use than others.

3. The colouring principle of many other substances resides in a purely resinous matter, insoluble in water, and some not even in spirit of wine; but they all are soluble in alkalis, which convert them into a kind of soaps, soluble in water. The principal colours of this nature employed in dying are the following:

A. The annatto, a kind of fecula, obtained by maceration of the seeds of the urucu putrefied in water. This fecula deposited during the putrefaction, is first red, and in process of time becomes of a brick dust



dust colour. The paste is mixed in water with the cendres gravelees, shortly to be described, and forms a bath, wherein the stuffs intended to be dyed are plunged. A gold, or orange yellow colour, of considerable beauty, is deposited without the assistance of a corrosive.

B. The flower of carthamus, or bastard saffron, affords a very fine red colour, by the same process. It contains two distinct colouring parts; the one purely extractive and soluble in water, the other resinous. In order to obtain the latter, the soluble part of the carthamus must first be carefully washed away. The remainder is mixed with the cendres gravelees, or salt of soda; and the mixture being lixiviated, forms a bath. But as the alkali alters the colour, and renders it dull, the dyed stuff is plunged in water rendered acid by lemon juice: the acid seizes the alkali, and leaves the colouring matter, which it enlivens, and causes to become red. A coloured fecula is obtained by a similar process, which, mixed with briançon chalk in powder, composes the rouge used by the ladies.

C. Archil is a paste prepared with mosses and lichen macerated in urine with lime: The latter disengages the volatile alkali, which develops the red colour. Archil mixed with water, affords a dye without any other preparation; with alkalis, it strikes a violet

a violet colour; but this is a false dye, which changes in the air, and becomes yellow by the action of acids.

D. Indigo, which is of a deep violet blue, of a coppery tinge, is a fecula prepared at St. Domingo, and in the Antilles, &c. by macerating the stalks of the anillo, or indigo plant, in stone troughs, with water. The water becomes blue, and after strong agitation the fecula precipitates. The indigo separated from the water, is put into cloths to drain, and after being dried in small wooden boxes, it is broken into pieces. It is esteemed good when it floats on water, and burns intirely away on a red-hot shovel. The colouring matter is extracted by alkalis, and applied, without any other preparation, to the stuffs. It cannot be brightened by acids, because they change its colour.

4. Certain colouring substances are soluble in oils. Alkanet, or the red root of a kind of bugloss, communicates its colour to oil. Spirit of wine likewise dissolves several colouring matters: green feculæ dissolve in this menstruum, as well as in oil. It may easily be conceived, that these colours are not used in dying, because the liquids necessary to extract them cannot be employed.

Such are the principal circumstances in which our knowledge of vegetable colours consists. Every immediate principle of vegetables may constitute the base of these co-

louring parts, since they are found of sapo-  
naceous, resinous, and extractive kinds.  
Some even appear to be of the nature of fat  
oils, being insoluble in water, or ardent  
spirit, though they readily combine with al-  
kalis. Lastly, there are some which are  
analagous to the glutinous part, according  
to Rouelle.

There is every reason to think, that fu-  
ture inquiries, if skilfully made, will dis-  
cover many other properties of these sub-  
stances, which greatly abound in vegetables,  
and that they will contribute to the im-  
provement of the art of dying; an art to  
which chemistry is well adapted to render  
the most important services.

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## C H A P. XVII.

Concerning the Analysis of Plants, by de-  
structive Distillation, or a naked Fire.

**A**FTER having examined all the sub-  
stances which may be obtained from  
plants, by simple methods, which are in-  
capable of changing them; and after having  
considered these matters as the immediate  
principles of organized substances, it is ne-  
cessary

cessary to attend to the alterations they suffer when exposed to heat.

The ancient chemists were acquainted with no other method of analysing vegetables, and all their researches into the nature of these bodies, consisted in determining how much spirit, oil, and volatile salt they afforded by distillation. This method is at present no longer esteemed, as it is known, that most plants afford nearly the same products; and the distillation of a great number of different vegetables, made by chemists, in other respects deserving the esteem of the public, has only served to undeceive us. In fact, how can it be imagined, that the action of fire, exerted on all the different principles in a vegetable substance, such as extract, mucilage, oil, resin, salt, gluten, &c. which decomposes each of these principles in a peculiar manner, can afford any knowledge respecting their nature and quantity; more especially when it is observed, that the products of these several decompositions unite together, and produce new substances, such as did not exist in the vegetable under examination? The analysis of vegetables, by distillation, is therefore complex and fallacious.

However, as none of the methods which art is in possession of, ought to be neglected, in the chemical examination of any substance, we may have occasional recourse to this ana-



lysis, always carefully observing, that it is not too much to be depended on. It sometimes happens, that when the effects of aqueous, spiritous, and oily menstrea, on any substance, are compared with the alterations produced in it by fire, these last confirm the deductions made from the action of the solvents, and by the products of the distillation, indicate the substances contained in greater or less quantities, the nature of its salts, &c. But to make valuable deductions from the analysis by fire, it is necessary, 1. To be well acquainted with the action of fire, on each immediate or proximate principle, such as extract, mucilage, saline matter, oily juices, the fluid, or solid part, &c. 2. To compare the products, afforded by distillation, of the whole vegetable, with those usually afforded by the proximate principles, treated in the same manner. 3. To analyze the vegetable by menstrooms, in order to obtain its proximate principles, and to make useful inductions from the alterations it has sustained by fire.

The process of distilling vegetables by a naked fire, is very easy and simple. A given quantity, of a dry vegetable, is put into a glass, or earthen retort, so as to fill it not more than half or two thirds; the retort is then placed in a reverbaratory furnace, and a receiver of a proper size adapted. It was formerly supposed necessary to use a receiver, perforated

perforated with a small hole, to give vent to the air said to be disengaged from vegetables, and tending to burst the vessels. But it is at present known, that the aeriform fluid, which escapes from these bodies during distillation, is scarcely ever air, but consists of cretaceous acid and inflammable gas. Now, as these elastic fluids are products of the vegetable compound, by fire, as well as the phlegm, the oils, and the volatile salts, it is equally necessary to collect them. For this purpose, a perforated receiver, communicating with an inverted glass vessel, filled with water or mercury, may be used. By this means, the liquid products are collected in the receiver, and the aeriform products under glass vessels, placed on the shelf of a pneumato-chemical apparatus. When the substance distilled affords a concrete salt, an adapter, or long glass vessel, is fixed between the retort and the receiver, in order that the sublimation may be made on its internal surface. The operation is begun, by placing a few pieces of lighted charcoal beneath the retort, and the fire is gradually increased till the vessel is red-hot, and nothing more comes over. After the whole has become cold, the apparatus is unluted, to examine each of the products obtained.

Though the distillation of vegetables never affords products which may be considered as principles of the plant, yet these products

differ considerably from each other, and require to be carefully distinguished.

The first product which comes over, is an aqueous liquor, containing certain odorous and saline principles. As the distillation advances, the colour and saline properties of this phlegm become stronger. It is succeeded by an oil, whose colour, consistence, and weight, gradually increase. From some vegetables, a light and fluid oil is obtained; but from others, a ponderous oil, capable of becoming concrete. The smell of this oil is always strong, and empyreumatic. During the time it comes over, a quantity of elastic fluid is disengaged, which consists either of the cretaceous acid, or inflammable gas, but most commonly of a mixture of both. At this period it is that the volatile alkali sublimes, when the vegetable is of such a nature as to afford it. When all these substances are past, the residue of the vegetable is of the nature of coal. We shall now proceed to examine more particularly into the nature and origin of each of these products.

The phlegm is produced from the water that enters into the composition of the vegetable, and partly from the water of vegetation, especially when the matter is not entirely dry; so that its quantity is greater or less on this account. The phlegm is coloured red, by a small quantity of oily matter

ter which rises, and is usually rendered saponaceous, by the salt contained in the fluid. The saline matter is most commonly acid; for which reason the phlegm usually reddens syrup of violets, and causes an effervescence with cretaceous alkalis. This acid arises from the mucilage, and the oil. But the phlegm is sometimes alkaline, as happens when nitrous or cruciferous plants, or emulsive and farinaceous seeds, are distilled; and it is often ammoniacal, because the volatile alkali succeeds the acid, and combines with it. This fact may be ascertained by the addition of a small quantity of quicklime, or alkali, by which a strong smell of volatile alkali will be produced, when ammoniacal salt is present. Though the acids of vegetables do not appear to be all of the same nature, those which are obtained, in their dissolution, exhibit the same external characters: but they have not yet been sufficiently examined to ascertain their properties with any degree of accuracy. The oils obtained from vegetables in this method, are all strong-smelling, highly-coloured, and possess nearly the same properties. Those parts of vegetables which contain a large quantity of these inflammable fluids, such as the emulsive seeds, afford a large quantity of oil in their analysis. Odoriferous plants afford an oil, which, at the beginning, slightly partakes of their peculiar smell, but quick-



ly assumes the characters of other oils of this kind, namely, colour, weight, and an empyreumatic smell. All these fluids are very inflammable; the nitrous acid sets them on fire, and they are soluble in spirit of wine. They may all, by rectification, be rendered very fluid, light, and colourless, and be converted into the state of etherial or essential oils.

The volatile salt, or ammoniacal chalk, is only obtained from certain vegetables; but it is not true, as some chemists have affirmed, that it is afforded only by the cruciferous plants. All plants in general, which contain a certain quantity of glutinous or vegeto-animal matter; afford more or less of volatile alkali, by virtue of the mephitic, shewn by Mr. Berthollet to exist in this vegetable principle. It is very seldom, however, that any considerable quantity is obtained in the concrete state, as it is usually dissolved in the last portions of the phlegm. This salt is produced by the union of the mephitic with the inflammable gas of the oil, and for this reason it most commonly passes over towards the end of the distillation. It even seems, that the volatile alkali, which rises with the phlegm in the analysis of certain plants, such as the cruciferous plants, poppy, rue, &c. is always the product of a new combination; since Rouelle the younger has shewn, that the plants them-

themselves do not contain it in their natural state.

The elastic fluids, disengaged during the distillation of vegetables, appear to depend on the nature of the vegetable. A plant, which contains a large quantity of oily combustible fluid, affords inflammable gas. Mucilages, on the contrary, afford cretaceous acid. We have observed, at the article of the acid of sugar, that Bergman and Fontana obtained a large quantity of cretaceous acid from that substance, and that the latter chemist thinks, that vegetable acids are for the most part composed of it. It is not, therefore, to be wondered, that mucilages, in which Bergman discovered the same acid as exists in sugar, should afford cretaceous acid. Lastly, there are some vegetable matters which afford atmospheric mephitic. These aeriform fluids are not extracted till near the end of the distillation, when the vegetable becomes intirely decomposed. Hales, who was not acquainted with their nature, observed, that the quantity of air disengaged during the distillation of vegetables is greater, the more solid they are; whence he concluded, that this element was the cementing principle and cause of solidity in bodies. It is easy to form a proper opinion of this hypothesis, from what has been already said.

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C H A P. XVIII.

## Of Vegetable Coal, or Charcoal.

**C**HARCOAL is the black residue of vegetables, which have suffered a complete decomposition of their volatile principles, in closed vessels. The property of affording charcoal is only observed in such organic substances as contain the combustible matter called oil. The formation of coal was formerly attributed, exclusively, to the decomposition of this last substance; but we begin to perceive, that the carbonaceous matter exists, ready formed, in vegetables, and that the action of fire merely separates the volatile principles.

Charcoal in general is black, brittle, sonorous, and light; it retains the form of the vegetable, provided its texture has been consistent, and the quantity of fluid not very great. If, on the contrary, a soft and succulent plant be decomposed, the volatile matters, during their disengagement, destroy the organic texture, and afford a friable coal, which does not possess the figure of the vegetable. The quantities of coal vary according to the solidity and texture of the vegetable.

vegetable. Wood affords more than herbs ; gums more than resins ; and these last, more than fluid oils. Each vegetable substance appears to contain it, in different quantities, if we consider charcoal as one of the immediate principles of this kingdom.

Charcoal is a substance which possesses very singular properties, for the most part little known. Though it is of the greatest importance in chemistry, and exhibits phenomena of the most singular kind, no chemist has yet attempted to discover its nature by a connected series of inquiries. Stahl, who attended more particularly to this substance than any other chemist, considers it as the principal repository of phlogiston. The knowledge we possess concerning the properties of charcoal, is almost intirely confined to its economical uses ; and the labours of philosophers exhibit nothing which can be called complete respecting it. The physical properties of charcoal differ according to the state and nature of the vegetable used in its formation ; it is sometimes hard, and, as we have observed, retains part of the organization of the vegetable : other specimens are friable, and pulverulent. Pure oils afford a coal, in very fine particles, known by the name of lamp-black. Its weight varies according to circumstances. When well made, it has neither taste nor smell in any sensible degree. Its colour is also sub-  
ject



ject to variation, and is of a black more or less deep, either shining or dull. But the most important inquiry, respecting this product of fire, relates to its chemical principles.

Charcoal, exposed to the most violent heat, in closed vessels, is not in the least altered. Heated in the pneumato-chemical apparatus, it does not afford inflammable gas, unless water be present. A strong fire reduces it into vapour. When heated with contact of air, it burns, and is reduced to ashes, but with peculiar phenomena, which it is essentially necessary to distinguish carefully from those of other combustible matters. When set on fire, it becomes red, and burns with a white flame, which is more considerable, the larger the mass. It emits no kind of smoke, but is converted into the elastic fluid, cretaceous acid, which, according to M. Lavoisier, is a combination of the carbonaceous and oxygenous principles, the latter forming three-fourths of the whole. In this manner the charcoal becomes gradually consumed, and leaves only ashes, more or less white, partly saline, and partly earthy. The different charcoals vary in their inflammability; a distinction which more particularly ascertains their utility in the arts. Some burn with flame, and are very quickly consumed; others do not take fire but with difficulty, burn slowly, and are not reduced  
to

to ashes but after a long ignition. There are some, as for example, the charcoal of oils, which do not burn but with the greatest difficulty. This character seems to depend on the adherence of the carbonaceous principle to the fixed salts of vegetables.

Charcoal, exposed to the air, attracts humidity, probably because it is very porous, and perhaps likewise by virtue of the salts it contains, though they be not in a disengaged state. When moistened, it affords inflammable air, by heat, which arises from the decomposition of the water; for when that fluid is passed in vapour through an earthen tube, filled with red-hot charcoal, these two bodies are converted into inflammable gas, and aeriform cretaceous acid. The residue is a small quantity of ashes. Rouelle has observed, that fixed alkali dissolves a considerable quantity of charcoal by fusion.

The vitriolic acid, strongly heated with charcoal, in powder, is decomposed by that combustible substance, which has a stronger affinity than sulphur with the oxygenous principle.

The nitrous acid is much more rapidly decomposed by charcoal. Dr. Priestley observed, that much nitrous gas is produced in this mixture. Macquer found, that the nitrous acid very sensibly effervesces with this body, by the assistance of heat. Mr. Proust has succeeded in setting fire to charcoal,

coal, by the addition of a nitrous acid, weighing one ounce four drachms and twenty-three grains, in a bottle which held an ounce of distilled water. The novelty and importance of his experiments are such, that I shall quote his own words, extracted from his observations on pyrophori made without alum, &c. inserted in the *Journal de Medicine* for July 1778.

“ Coal from the extract of carthamus, reduced to powder, and recently calcined, detonated very strongly with the nitrous acid; and the rapidity with which the mixture took fire, threw up the powder in the form of a very beautiful fire-work. I calcined very fine powder of common charcoal, and the detonation succeeded very well.

“ I introduced about a drachm of the powder of charcoal into a very dry glass retort; I then poured in about a drachm of nitrous acid, which had no sooner reached the bottom of the retort, than the detonation took place with the greatest rapidity: a flame of more than four inches in length issued out of neck of the retort while I held it in my hand, which carried with it the powder, and very deep-coloured vapours of nitrous acid. These vapours condensed into a green liquor, scarcely fuming: it consisted of the nitrous acid, weakened by the water  
“ which

“ which entered into the combination of  
“ that which detonated first. I poured new  
“ nitrous acid on the charcoal which re-  
“ mained in the retort, and continued the  
“ process till the whole was intirely de-  
“ stroyed by successive inflammation.

“ I repeated this experiment with cal-  
“ cined lamp-black; the events were the  
“ same: the retort was found to contain  
“ only a small portion of ashes, sometimes  
“ semi-vitrified, and adhering to the bottom  
“ of the retort.

“ All charcoals in general attract a con-  
“ siderable quantity of humidity. It ap-  
“ peared to me, that charcoal calcined in  
“ the evening, and kept till the next morn-  
“ ing, was no longer proper for these ex-  
“ periments, because it became sensibly  
“ moistened in that space of time. But the  
“ most singular circumstance is, that these  
“ experiments are capricious, and do not  
“ always succeed, though with the same  
“ charcoal, the same acid, and the same  
“ proportions. The following manipula-  
“ tion appeared to me to insure success. If  
“ the acid be poured in the middle of the  
“ powder, it does not take fire: but if,  
“ on the contrary, it be suffered to run  
“ down the side of the capsule, or crucible,  
“ so as to occupy the lower place, the de-  
“ tonation is made from that point; the  
“ powder rises and takes fire, by the nitrous  
“ acid.



“ acid. When nitrous acid is wanting, the  
“ detonation ceases of itself, and the sur-  
“ rounding charcoal remains black.”

The action of the other acids on charcoal is not known.

This substance, assisted by heat, decomposes all the vitriolic salts, and forms livers of sulphur.

It causes nitre to detonate, which burns it, by means of the pure air afforded from the salt by the action of the fire. A preparation is made for chemical and pharmaceutical purposes, called nitre, fixed by charcoal. Two parts of nitre, and one of powdered charcoal, are mixed, and thrown into a red-hot crucible on the fire. A strong detonation ensues, after which a white mass remains, consisting of the fixed alkali of the nitre and of the charcoal. By lixiviating this mixture, the water dissolves the fixed alkali, and leaves a substance supposed to be an earth.

Liver of sulphur dissolves charcoal very readily, both by the dry and moist way, and even combines with it more readily than any other substance. This discovery is due to Rouelle.

Metals do not unite with charcoal, but their calces recover the metallic state when heated with this substance. We have seen, at the article of metals, that this phenomenon may readily be accounted for, from the affinity of the oxygenous principle with the carbonaceous principle.

The

The action of vegetable substances on charcoal has not been much examined. It is only known, that a mixture of this substance with fat oils renders them inflammable by the nitrous acid; a circumstance which confirms the theory of Rouelle respecting the inflammation of oils by this acid.

All the facts here related, concerning the known properties of charcoal, tend to prove, that this body is composed of combustible matter, salts, and earths.

The peculiar combustible matter which constitutes more than three-fourths of charcoal, or the carbonaceous principle properly so called, is as yet scarcely at all known. It appears, however, to have the strongest affinity with the oxygenous principle, which it takes from almost every other body, and that in many particulars it resembles plumbago.

The various uses of charcoal in the arts, and in chemistry, are well known.

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C H A P. XIX.

## Concerning the Fixed Salts and Earths of Vegetables.

**W**HEN a vegetable coal has been burned, a grey, blackish, or white matter remains, according to the nature of the charcoal. This substance, called ashes, is very compounded; when well made, it contains only saline and earthy substances, mixed with iron, and a small quantity of manganese. When the charcoal has been burned with difficulty, the ashes still retain a small portion of inflammable matter. M. Lavoisier, on examining the wood ashes used by the saltpetre-makers, found them to contain extractive and resinous-extractive matters. The saline substances obtained, by lixiviation, from ashes, have been called the fixed salts of plants. The incineration of vegetables is used for obtaining three kinds of salts, which we shall here describe.

1. Pot-ash, from which the vegetable fixed alkali is obtained, is prepared in the north, by burning wood, with which those countries abound. This salt is very impure; it often contains combustible matters, which diminish its whiteness, and frequently neutral

tral salts, such as the vitriols of pot-ash, of soda, and of lime, the muriates of pot-ash and of soda, a small quantity of cretaceous soda, with iron and earthy substances. To purify this salt, it is dissolved in the smallest possible quantity of cold water. The fluid becomes charged with the alkali, and some of the neutral salts; and the earth, the charcoal, the iron, and the selenite, often contained in pot-ash, are separated by the filter. This solution is then evaporated to a pellicle, and the several salts it contains are suffered to crystallize by cooling. After several filtrations, evaporations, and crystallizations, when the lixivium no longer affords any neutral salt, it is evaporated to dryness, and calcined. The salt is then cretaceous vegetable alkali, mixed with the same alkali in a caustic state: it seems, however, always to contain some neutral salts, and a small quantity of earthy substance, which is deposited by standing, and may be separated by the filter. After which, it may be used in the nicest chemical experiments.

2. Soda, from which the mineral alkali is obtained, is the residue of the combustion of plants that grow on the sea coasts. It is prepared at Alicant in Spain, in Languedoc, at Cherbourg, &c. by burning various species of plants. At Alicant, they use the kalis; and at Cherbourg, the algas, and fucus, commonly known by the name of



varech. The first plant contains a much greater quantity of mineral alkali than the second, which affords scarcely any. These different plants are burned in a trench. At Cherbourg, when the combustion is advanced, and the ashes are very hot, they are strongly agitated, and kneaded together with large poles. By this motion, the substance, which is sufficiently hot to undergo a kind of semi-vitrification, takes the form of hard and solid lumps, known in commerce by the name of salicore, salicote, lamarie, and alun catin. The names, by which it is more particularly distinguished, denote either the plant from which it was obtained, or the country where it was made. The soda of Alicant, likewise called barilla, is the best for chemical purposes, and those arts which require much mineral alkali. The soda of Cherbourg, or of varech, contains less alkali, and ought not to be used in chemical experiments; but it is advantageously used in the manufacture of glass, because the vitreous frit it affords is found to be very serviceable in that manufacture.

The soda of commerce, chemically considered, is a compound of caustic soda, cretaceous soda, cretaceous vegetable alkali in a small quantity, vitriols of pot-ash and of soda, marine salt, charcoal, iron in the state of Prussian blue, according to the observation of Henckel, and earth, partly disengaged, and partly

partly combined with fixed alkali, as in that of Cherbourg. To separate these substances, and obtain pure cretaceous soda, it is dissolved in cold distilled water, and filtered, to separate the earth, iron, and coaly matter; after which it is evaporated, as we have observed concerning pot-ash. This alkali is purified more easily than that of pot-ash, because, as it crystallizes more readily, it can be better separated from the portion of caustic soda; yet it contains some of the neutral salts, and Prussian blue, when first crystallized, which must be separated by repeated solutions and crystallizations.

3. Fixed salts are prepared in pharmacy, which have been greatly recommended by Tachenius, and are still distinguished by his name. The process of this chemist consists in placing the plant, whose salt is proposed to be obtained, in an iron pot. This vessel is heated till its bottom is red hot; the plant, which is continually stirred, emits much smoke, and takes fire, at which time the pot is covered, so that the smoke may be dissipated, and the flame extinguished. By this means, the plant is gradually consumed. When reduced to a kind of blackish ashes, it is lixiviated with boiling water, which affords a yellowish, or brown salt, by evaporation to dryness. This salt is often alkaline, but is very impure; it is coloured by much extractive matter, which is mixed with

all the neutral salts the plant contained. As it is a saponaceous compound, good effects often follow its use; but it cannot be supposed to possess the same virtues as the plant from which it was extracted, because its principles have necessarily been altered by the combustion. It would be of considerable use to examine, analytically, the different fixed salts of plants, prepared after the manner of Tachenius, in order to discover the saline and extractive matters they contain, and to determine their virtues, and the dose in which each ought to be administered.

4. When all the saline matter is washed off from the ashes of vegetables, the remainder is a pulverulent substance, more or less white, or coloured, insipid, insoluble in water, and hitherto considered as an earthy substance.

Iron may be extracted from this residuum by the magnet. This metal, as well as the manganese which vegetable ashes have lately been found to contain, existed, ready formed, in the vegetable. Many philosophers have supposed, that the colours of plants are produced by iron. Mr. Baumé, who, in his memoir concerning clays, has mentioned the earthy residue of vegetables, affirms, that it forms alum with the vitriolic acid, and likewise selenite, slightly differing from that which is produced by pure calcareous earth. The other acids afford, with this residue, spathose

spathose salts, and a small portion of martial salts. Hence Mr. Baumé thinks that the earth of vegetables consists of clay, and an earth resembling calcareous earth, though it sensibly differs from it, according to him, in not forming quick-lime by the action of fire. He thinks, that the clay is formed in these organized substances by the collision to which vitrifiable earth is exposed, and the action of acids with which it combines; that the clay, once formed, passes to the state of calcareous earth, by successive elaborations in the tubes of vegetables.

We may here observe, that the discoveries made in Sweden, on the saline nature of bones, which appear to be the same with respect to animals as the fibrous parts are in vegetable substances, render it probable, that this residue is far from being merely an earth. An accurate analysis, such as has not hitherto been made, may shew, that this supposed earthy substance is calcareous phosphate; at least we may suspect this to be the case, since the experiments of Margraaf and Berthollet, who have obtained phosphorus from mustard seed, from gluten, and from several other vegetable substances,



## C H A P. XX.

Concerning Fermentation in general, and  
the Spirituous Fermentation in particular.

**A**FTER having considered vegetables in the state in which they naturally exist, we shall proceed to describe the changes they experience in different circumstances. These alterations, which intirely depend on their nature, are always the consequence of a phenomenon called fermentation.

Fermentation is a spontaneous commotion in a vegetable substance, by which its properties are totally changed. This commotion is peculiar to the fluids of organic matters; no other substances, except those which have been elaborated by the principle of vegetable or animal life, being susceptible of it. Chemists have not sufficiently attended to this important truth, whose application to the phenomena which take place in organized bodies, cannot but be of the greatest use in medicine.

There are several circumstances required in order that fermentation may proceed. Such are,

1. A

1. A certain degree of fluidity : dry substances, in fact, do not ferment at all.

2. A certain degree of heat. Each kind of fermentation requires a due degree of heat, but cold stops the progress of every ferment.

3. The contact of air. On this account it is, that organized substances are very well preserved, and are not altered in a vacuum.

Chemists, after Boerhaave, have distinguished three kinds of fermentation: the spirituous, which affords ardent spirit; the acetous, which affords vinegar, or acid; and the putrid fermentation, or putrefaction, which produces the volatile alkali. It must be observed, that there are many fermentatory processes which do not seem to belong to these three kinds; such, perhaps, are the fermentations of bread, of mucilages, that which develops the colouring parts, &c. It has been thought, that the fermentations always follow each other in the order we have mentioned; but there are bodies which become acid, without having previously undergone the spirituous fermentation; and there are others which putrify without passing through the two first stages. We may likewise observe, that the intestine motion of maturation appears to constitute a kind of fermentation, by which saccharine matter is produced or disengaged.

The spirituous fermentation, or that which produces

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produces ardent spirit, may be considered with respect to, 1. The conditions necessary to its production; 2. The phenomena which accompany it; 3. The several substances susceptible of this fermentation; 4. Its cause; and, 5. Its products.

Experience has shewn, that all vegetable matters are not capable of passing to the spirituous fermentation, but that the union of several peculiar circumstances is necessary for this purpose.

These conditions are, 1. A saccharine mucilage. This substance only is capable of passing to the spirituous fermentation.

2. A degree of fluidity, slightly viscid. If the vegetable fluid be either too thick, or too thin, it will not ferment.

3. A degree of heat, from ten to fifteen degrees of Reaumur's thermometer, or between fifty-five and sixty-five of Fahrenheit.

4. A large mass, in which a rapid commotion may be excited.

When these four conditions are united, the spirituous fermentation takes place, and is known by the following characteristic phenomena.

1. An intestine motion is excited in the liquor, which increases till the fermentation is well established.

2. The bulk of the mixture is quickly augmented, and this augmentation follows the progress of the intestine motion.

3. The

3. The transparency of the fluid is diminished by opaque filaments, which are agitated, and carried to every part of the fluid.

4. A degree of heat is produced, equal to eighteen degrees, (seventy-two and a half Fahrenheit) according to the Abbé Rozier.

5. The solid parts, mixed with the liquor, rise and float, in consequence of the disengagement of elastic fluid.

6. A large quantity of cretaceous acid gas is disengaged. This gas forms a stratum in the upper part of the fermenting vats, which may be easily distinguished from air. In this stratum it was, that Dr. Priestley and Duc de Chaulnes made their valuable experiments. Candles, plunged in this stratum, are extinguished, and animals die therein; lime-water is precipitated, and caustic alkalis crystallize perfectly. This acid, contained in the fermenting vats of brew-houses, frequently produces the most fatal effects on the workmen.

7. The disengagement of this gas is accompanied with the formation of a great number of bubbles in the viscid liquor, through which the cretaceous acid must pass.

All these phenomena gradually cease, in proportion as the liquor loses its sweet and mild taste, and becomes brisk, penetrating, and capable of producing intoxication.

Necessity has induced mankind to prepare  
fermented



fermented liquids with a great number of different vegetable substances; but experience has shewn, that saccharine matters alone are capable of forming this kind of fluid. The following being most commonly used, require to be enumerated.

1. The juice of grapes produces wine, properly so called: it is the best of all fermented liquors. The art of cultivating vines, which is of great importance, requires an attention to the following objects. 1. The nature of the soil. It is known, that a dry soil is in general well adapted to this plant, and that a strong soil does not agree with it. 2. The cultivation of this vegetable. It is pruned; its branches are bent, to impede the course of the sap; care is taken that it be exposed to the heat of the sun, and more especially to the heat reflected from the earth, &c. It is not manured, &c. 3. The history of its vegetation, its exposition, its flowering, the formation and ripening of the grape. 4. The accidents to which it is exposed, such as frost, heavy rain, moisture, &c. 5. The time of vintage, which should be dry and hot. These preliminary circumstances being known, the art of making wine is to be considered, which consists in putting the stalked grapes into a vessel, exposed to a heat of fifteen or sixteen degrees, to break, agitate, and turn them over. When the fermentation is excited, and all its phenomena

phenomena take place, the juice of grapes, or must, should be neither too fluid, nor too thick; in the first case, it requires to be thickened by boiling; in the latter, it is diluted with water. When the wine is made, it is drawn off into casks, which are left open, where it experiences a second insensible fermentation, by which its principles are more intimately combined; a fine lye, and a salt, known by the name of tartar, being precipitated. To preserve the wine, rags, dipped in sulphur, are burned in the cask which contains it.

The knowledge of the different kinds of wine is an object of considerable importance. France produces a great number of excellent wines. Those of Burgundy are preferable to any other for constant use, because their principles are perfectly combined, and no one predominates over the other. The wines of the province of Orleans resemble those of Burgundy, when they have been matured by keeping, which combines the excess of ardent spirit they contain with their other principles. The red wines of Champagne are excellent, and of a delicate flavour. The white wine of this province, which does not sparkle, is to be preferred to the sparkling wine, whose penetrating and subacid taste, as well as its property of sparkling, depend on the cretaceous acid contained in it, when bottled before the fermentation

mentation was finished. The wines of Languedoc and Guienne are of a deep colour, and are excellent bracers and stomachics, especially when of a good old age. The wines of Anjou are white, very spirituous, and intoxicate quickly.

As to foreign wines, those of Germany, known by the name of Rhenish and Moselle, are white, and very spirituous; their taste is keen and penetrating, and they quickly produce intoxication. Some wines of Italy, such as those of Orvieto, Vicenza, the Lachryma Christi, &c. are well fermented, and resemble the good wines of France. Those of Spain and of Greece are in general sweet, crude, imperfectly fermented, and very unwholesome. We must, however, except those of Rota and Alicant, which are with justice esteemed to be stomachic and cordial.

2. Apples and pears afford cyder and perry. This species of wine is very good, and affords good brandy, as M. d'Arcet has shewn.

3. Cherries afford a tolerable good wine, from which a kind of brandy is distilled, called Kirchenwasser by the Germans.

4. Apricots, peaches, and plumbs, afford a wine of inferior quality.

5. Sugar, dissolved in water, ferments readily: from this kind of wine, a spirit, called rum, taffia, guildive, &c. is made.

6. The

6. The seeds of gramineous plants, and especially barley, afford a species of wine, called beer. The art of brewing consists in the following processes. Barley is steeped in water for thirty or forty hours, after which it is laid in a heap, to sprout or germinate; it is then dried in a kiln, and the buds separated by sifting; after which it is coarsely ground, and is distinguished by the name of malt. A certain quantity of malt is put into a vessel, called the mash-tun, on which water, nearly boiling-hot, is poured, which dissolves the mucilage. This being drawn off, a second quantity of heated water is poured on the malt, and in like manner drawn off. This fluid, called wort, is boiled up with hops, and is put, together with yeast, into a vessel, called the cooler. When the fermentation begins to subside, the beer is stirred up, and drawn off into casks; the second fermentation throws up a scum, called yeast, which serves to excite fermentation in future brewings. The germination develops a saccharine matter in the barley, to which it owes its property of forming wine: the same process succeeds with most other gramineous seeds.

The whole of these facts prove, that the saccharine matter is the only principle of vegetables capable of passing to the spirituous fermentation, and that water is necessary for the production of this intestine motion. M.

Lavoisier



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Lavoisier thinks, that this fluid is decomposed in the operation: the oxygenous principle seizes the carbonaceous matter of the sugar, and forms cretaceous or carbonaceous acid, which is disengaged during this fermentation; while the base of the inflammable gas unites with the oil of the saccharine substance, and forms a very light combustible subtle body, containing much less carbonaceous matter than the sugar, and much more inflammable: this is ardent spirit.

The product of all these fermenting substances, is a liquor more or less coloured, of an aromatic smell, a penetrating and hot taste, which, in small doses, assists the action of weak fibres, but produces intoxication when taken too largely. It is universally known by the name of wine.

The wine of grapes, for example, is composed of a large quantity of water, ardent spirit, an essential salt called tartar, and an extracto-resinous matter, which produces the colour in red wines.

Before we proceed to describe the methods of separating these substances, it will be proper to describe the uses and properties of the fluid itself. Wine dissolves many substances, by virtue of the water, the ardent spirit, and the essential acid salt, of which it is formed. It unites with extracts, resins, certain metals, &c. On these properties depend

depend the preparations of medicinal wines, such as, 1. Emetic wine, prepared by macerating four ounces of crocus metallorum in two pounds of good white wine; the liquid is filtered, or is used without filtration, in paralytic or apoplectic cases. 2. Chalybeate wine, made by digesting one ounce of steel filings with two pounds of white wine: it is an excellent tonic and aperitive medicine. 3. The wines of vegetables, prepared (a) either with red wine, in which astringent or aromatic plants are macerated; (b) or with white wine, which is usually employed with antiscorbutic plants; (c) or with Spanish wine: the wine of Squills, and also the liquid laudanum of Sydenham, are prepared with this wine. The latter is made by digesting two ounces of sliced opium, one ounce of saffron, a drachm of powdered cinnamon and cloves, in a pound of Spanish wine. This medicine is a very good sedative, taken in the dose of a few drops, especially in cases in which it is feared that opium may weaken the patient, or stop some useful evacuation.

The action of fire is commonly used to decompose wine, and separate it into its several principles. The distillation is performed in an alembic of tinned copper, to which a receiver is adapted: as soon as the wine boils, a colourless fluid, slightly opaque, and milky, of a hot and penetrating taste, and a

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strong agreeable smell, comes over. This fluid is received, till the vapours no longer take fire by a candle. It is called brandy, and consists of water, ardent spirit, and a small portion of oil, which renders it milky at first, and after a certain time colours it yellow. The colour of old brandy, in commerce, does not, however, arise from the oil alone, which comes over in the distillation, but likewise from the extractive matter it takes from the cask in which it is contained. Brandy is the fluid from which ardent spirit is extracted, as we shall hereafter see. The residual liquor, after it has afforded spirit of wine, is of an acid austere taste, turbid, and deposits a large quantity of saline crystals, which appear to be tartar. The wine is therefore intirely decomposed, and cannot be restored to its former properties by combining the spirituous product with the residue. Hence the analysis appears to be complicated. If the residue of wine which has afforded brandy be evaporated, it takes the form and consistence of an extract. The colouring part may be separated by the addition of spirit of wine, which does not act on the tartar. Water does not precipitate this tincture. By evaporation of the tincture to dryness, a residue is obtained, which quickly takes fire, and is soluble in water; it is a true resino-extractive substance, which the ardent spirit, formed by  
fermen-

fermentation, has extracted from the skins of the grapes. From this analysis it appears, that wine consists of water, ardent spirit, tartar, and colouring matter; we have already explained the nature and properties of two of these substances, namely, water, and the colouring extract; ardent spirit and tartar remain, therefore, to be treated of.

Before we proceed to speak of these, we shall take notice of a substance that precipitates from wine during its fermentation, and is called lees. It consists of the seeds and skins of grapes, impure tartar, and vitriolated tartar. By distillation with a naked fire, it affords brandy: treated in a retort, it affords acid phlegm, oil, volatile alkali, and its coal contains cretaceous vegetable alkali and vitriolated tartar. The incineration of the lees of wine, in the open air, affords a caustic fixed vegetable alkali, mixed with vitriolated tartar, and known in commerce by the name of *cendres gravelées*. The account we shall proceed to give of spirit of wine, and of tartar, will complete what remains to be said concerning the lees of wine.



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C H A P. XXI.

Of Ardent Spirit, or the Product of the Spirituous Fermentation.

**W**E have seen that brandy, obtained by distilling wine with a naked fire, is a compound of ardent spirit, water, and a small portion of oil. Distillation is used to separate these substances, and to obtain ardent spirit in a state of purity. There are several methods of distilling spirits of wine. M. Baumé advises to distill brandy a considerable number of times, by a water-bath, to obtain all its spirit. He recommends the separation of the first fourth part of the product of the first distillation, and likewise of the first half of the product of the following distillations; to mix all these together, and to rectify by a gentle heat. The first half of the fluid, which passes in this rectification, is the purest ardent spirit, called alkohol; the remainder is less strong, but very good for ordinary purposes. Rouelle directs, that half the brandy made use of, be drawn off by distillation on the water-bath; this first product is common spirit of wine, which, being rectified twice, and reduced to about  
two-

two-thirds, becomes a stronger spirit. This is to be again distilled with water, according to the process of Kunckel, which separates the oil; the distilled spirit, being again rectified, may be depended on as perfectly pure. The residue of brandy, after distillation, is water, containing colouring matter, on the top of which a peculiar oil floats.

Hence it may be observed, that the purity and strength of ardent spirit must differ according to the processes used in obtaining it. A method of discovering its purity has long been sought after. It was formerly supposed, that spirit of wine, which readily catches fire, and leaves no residue, is very pure; but it is at present well known, that the heat excited by its combustion is sufficiently strong to dissipate all the phlegm it might contain. Another proof has been proposed, by means of gunpowder: when spirit of wine, set on fire in a spoon upon gunpowder, does not inflame it, it is considered as bad; if, on the contrary, it sets it on fire, it is judged to be excellent. But this proof is very fallacious; for when a large quantity of the best spirit of wine is burned on a small quantity of gunpowder, the water it affords during its combustion moistens the powder, and prevents its taking fire; whereas it may be inflamed by burning a very small quantity of phlegmatic spirit of wine on its surface. This method is

therefore no more to be depended on than the former. Boerhaave has described a very good process for ascertaining the purity of this fluid: it consists in throwing the very dry powder of fixed salt of tartar into spirit of wine; this unites with the superfluous water of the spirit, and forms a more ponderous and coloured fluid than the ardent spirit, with which it does not mix, but falls to the bottom. Lastly, M. Baumé, on the consideration that spirit of wine is lighter the purer it is, has contrived an areometer, by which the degree of purity of this fluid may be accurately ascertained. When the instrument is plunged in spirit of wine, it sinks deeper, in proportion as the fluid is purer. By experiments carefully made, he has determined, that the purest and most highly rectified spirit of wine gives thirty-eight degrees of his areometer. The method of constructing this instrument, as well as the results afforded by different quantities of spirit of wine, may be seen in his elements of pharmacy, and may be applied to determine the strength of spirit of wine by the hydrometer.\*

Pure

\* Notwithstanding the labours of many ingenious chemists, and particularly those of Mr. Bories, related in his Memoir, which obtained the prize proposed by the states of Languedoc, in 1772, and published at Montpellier in the year 1774, much remains to be done before the strength

Pure ardent spirit, obtained by the process we have described, is transparent, exceedingly fluid, and so light, that it weighs four hundred and eighty grains, in a bottle which contains five hundred and seventy-six grains of distilled water. Its smell is penetrating, and agreeable; its taste is hot, and strong. It is extremely volatile, rising and passing over in close vessels, by a very gentle heat, and is by this means

K 4

separated

strength of spirits can be determined, with sufficient accuracy even for commercial purposes. If ardent spirit, which is so highly dephlegmated as not to liquefy hot pulverized alkali, be considered as pure spirit, or the standard extreme, distilled water forming the other extreme, it will then be necessary to ascertain, by experiment, 1. The specific gravity of a certain number of mixtures of water and this spirit, taken so near each other, as that the intermediate specific gravities may not sensibly differ from those deduced mathematically in the usual manner. 2. The expansions, or variations of specific gravity of these mixtures, at the different temperatures of the atmosphere. 3. The change of specific gravity, produced by the solution of saccharine or oleaginous substances in these spirits. 4. Easy methods must be devised to shew the presence and quantity of the last mentioned substances; and also, 5. To determine the specific gravity of the fluid.

These requisites demand a great number of accurate experiments to be made. Rectified ardent spirit, repeatedly affused on dry alkali, till it would no longer dissolve or liquefy it, was found, by Mr. Bories, by many experiments, to have the following specific gravity.

Reaumur's Therm.

|   |     |   |                                      |
|---|-----|---|--------------------------------------|
| + | 10° | = | 820 <sup>2800</sup> / <sub>333</sub> |
| + | 15° | = | 817 <sup>65</sup> / <sub>333</sub>   |
| + | 20° | = | 813 <sup>285</sup> / <sub>333</sub>  |

The



separated from the small quantity of water it might contain. The first portions are the most volatile, and pure. It was formerly thought, that a large quantity of air was always disengaged during the distillation of spirit of wine. This supposed air is now known to be the spirit itself, in the form of gas.

When ardent spirit is heated with the contact of air, it soon takes fire, and exhibits a light flame, white in the middle, and blue at the sides; it completely burns away, when pure. Many chemists have at-

The specific gravities of mixtures, by measure; of the foregoing spirit with distilled water, were as under.

Temperature  $\div 15^{\circ}$  Reaumur.

| Spirit | 10 | Water | 0  | Specific gravity | 817 <sup>65</sup> <sub>3033</sub>  |
|--------|----|-------|----|------------------|------------------------------------|
|        | 9  | -     | 1  | -                | 844 <sup>580</sup> <sub>3033</sub> |
|        | 8  | -     | 2  | -                | 869 <sup>470</sup> <sub>3033</sub> |
|        | 7  | -     | 3  | -                | 893 <sup>380</sup> <sub>3033</sub> |
|        | 6  | -     | 4  | -                | 915 <sup>305</sup> <sub>3033</sub> |
|        | 5  | -     | 5  | -                | 934 <sup>230</sup> <sub>3033</sub> |
|        | 4  | -     | 6  | -                | 951 <sup>160</sup> <sub>3033</sub> |
|        | 3  | -     | 7  | -                | 965 <sup>105</sup> <sub>3033</sub> |
|        | 2  | -     | 8  | -                | 976 <sup>50</sup> <sub>3033</sub>  |
|        | 1  | -     | 9  | -                | 987 <sup>0</sup> <sub>3033</sub>   |
|        | 0  | -     | 10 | -                | 1,000                              |

I find, by distilling 20 measures of the best spirit of wine of the shops, (Sp. Gr. = 836) in glass vessels, by a lamp, that the first measure which came over had a specific gravity of 820, at a temperature of  $71^{\circ}$  of Fahrenheit, or about  $\div 17\frac{1}{2}$  of Reaumur. This, which is the strongest spirit mere distillation can afford, contains about one part in the hundred of water, of which it may be deprived by alkali. Note of the Translator.

tempted

tempted to discover the product afforded by spirit of wine in burning. They found that its flame is accompanied with neither soot nor smoke; and that the volatilized matters when condensed, are pure water, without taste or smell, absolutely in the state of distilled water. Boerhaave, from this phenomenon, supposed, that the flame is produced by the water; and this opinion is confirmed by the knowledge we at present possess, respecting the inflammable air obtained by the decomposition of water, and the water obtained by burning inflammable gas. Mr. Lavoisier discovered, that when spirit of wine is burned in a chimney adapted to receive the vapours, a larger quantity of water is obtained than the whole of the spirit made use of amounts to; whence it follows, that this liquor contains a large quantity of inflammable gas. On the other hand, Mr. Berthollet has remarked, that when a mixture of this spirit and water is burned, the residual fluid precipitates lime-water. This experiment shews, that ardent spirit contains a small quantity of carbonaceous matter, which, by its combustion or combination with the oxygenous principle, forms the cretaceous acid. Chemists have adopted different opinions respecting ardent spirit; Stahl, Boerhaave, and some others, have considered this fluid as a compound of a very attenuated oil, a subtle acid, and  
water.

water. Others, at the head of whom may be placed Cartheuser and Macquer, think that spirit of wine is formed by the union of phlogiston and water. The nature of this fluid is not yet well known. Spirit of wine, exposed to the air, evaporates at a temperature of  $55^{\circ}$ , and leaves no residue, except a small quantity of water, when it has not been well dephlegmated. This evaporation in the air is more rapid, the hotter the atmosphere; and produces a degree of cold, which is stronger in proportion to its rapidity. Spirit of wine has the form of an elastic fluid at  $185$  degrees of Fahrenheit's thermometer.

Spirit of wine unites with water in all proportions, and is perfectly soluble in that fluid. This solution is attended with heat, and produces mixtures, whose strengths are greater in proportion as the quantity of ardent spirit is greater. The affinity of combination between these two fluids is so strong, that water is capable of separating spirit of wine from many bodies with which it may be combined; and on the contrary, spirit of wine decomposes most saline solutions, and precipitates the salts. From the consideration of this last property, it is, that Boulduc proposes the use of spirit of wine to precipitate the salts contained in mineral waters, and to obtain them unaltered.

Spirit of wine has no action on pure earths.

earths. It is not known whether it is altered by ponderous earth and magnesia. Lime appears capable of producing some change in this fluid, since it acquires a degree of smell when distilled from that earthy substance. But this alteration has not been properly inquired into.

Fixed alkalis appear really to decompose spirit of wine, as is known by the medical preparation called the acrid tincture of tartar. To prepare this, pot-ash is melted in a crucible, pulverized while hot, and put into a matrafs; highly dephlegmated spirit of wine is poured on, to three or four fingers depth; the matrafs is closed with another of a smaller size, luted together, and the whole is digested on a sand bath, till the spirit has acquired a reddish colour. A great or less quantity of alkali remains at the bottom of the vessel. This acrid tincture of tartar affords, by distillation, a spirit of wine of a sweet smell, scarcely altered; and a substance remains in the retort resembling a saponaceous extract, which distilled with a naked fire, affords spirit of wine, volatile alkaline spirit, and a light empyreumatic oil. In this operation, a small quantity of charcoal is formed, which is found to contain the vegetable alkali. The experiment seems to shew, that spirit of wine contains an oil which is seized by the fixed alkali, and forms a true soap kept in solution



water. Others, at the head of whom may be placed Cartheuser and Macquer, think that spirit of wine is formed by the union of phlogiston and water. The nature of this fluid is not yet well known. Spirit of wine, exposed to the air, evaporates at a temperature of  $55^{\circ}$ , and leaves no residue, except a small quantity of water, when it has not been well dephlegmated. This evaporation in the air is more rapid, the hotter the atmosphere; and produces a degree of cold, which is stronger in proportion to its rapidity. Spirit of wine has the form of an elastic fluid at  $185$  degrees of Fahrenheit's thermometer.

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lution in the portion of ardent spirit which is not decomposed. The liliū of Paracelsus does not differ from the acrid tincture of tartar, excepting that the fixed alkali employed in its preparation appears to be rendered caustic by the metallic calces with which it was heated. The martial, jovial, and cupreous reguli of antimony, each in the quantity of four ounces, are fused together, then reduced into powder, and detonated with eighteen ounces of tartar, and as many of nitre; the whole being melted, pulverized, and put into a matraass, highly rectified spirit of wine is poured on, to the height of three or four inches above the mixture. By digestion on a sand bath, the spirit assumes a beautiful red colour, deeper than that of the preceding tincture, but presenting the same phenomena. The former tincture may be made intirely similar to the liliū of Paracelsus, by digesting spirit of wine in the caustic fixed alkali, instead of using salt of tartar, which is not deprived of its cretaceous acid, unless it has been kept red hot a long time. Mr. Berthollet ascertained that these tinctures are merely solutions of caustic vegetable alkali in spirit of wine, and that they afford an useful method of obtaining the alkali very pure, by evaporation of the spirit. Spirit of wine has the same action on pure soda. The acrid tinctures of tartar are excellent bracers, and powerful deobstruents.

deobstruents. They are used in those cases where the natural forces of the patient are insufficient to favour the crisis, as in the malignant fever, the worst kind of small pox, &c.

The action of the caustic volatile alkali on spirit of wine has not yet been examined.

All the acids present very important phenomena with this spirituous fluid. When concentrated oil of vitriol is poured on an equal quantity of rectified spirit of wine, a strong heat, with a remarkable hissing noise, is produced; the two substances become coloured, and emit a sweet smell, resembling that of lemons, or the apple called golden rennet. If the retort, in which this mixture is usually made, be placed on a sand bath with large receivers adapted, the first being plunged in a vessel of cold water, the products are, 1. A spirit of wine of a sweet smell. 2. A fluid called ether, of a very agreeable smell, extremely volatile, whose presence is ascertained by the ebullition of the liquor contained in the retort, and by the large striæ which run down the sides of the vessel. The receiver must now be kept cool by wet cloths. 3. After the ether, a sulphureous spirit passes, whose white colour and smell indicate the proper time for changing the receiver, in order to have the ether separate. 4. At the same time a light yellowish



lowish oil is volatilized, which is called sweet oil of wine. The fire must be greatly lowered after the ether is passed, because the matter contained in the retort is black, thick, and swells up considerably. 5. When the sweet oil is all distilled, sulphureous acid next comes over, which becomes thicker and thicker; and towards the end dirty and black oil of vitriol. 6. The operation being continued by a gentle heat, the residue becomes perfectly dry, and has the form and consistence of a bitumen. By exposure to a strong heat, an acid liquor and a dry and yellowish substance resembling sulphur, is obtained. M. Baumé, who has made a great number of experiments on vitriolic ether, has very carefully examined this residue, and found it to contain martial vitriol, Prussian blue, a saline substance, and a peculiar earth, whose nature he has not ascertained. He even affirms, that the yellowish sublimate it affords, is not sulphur, but that it remains white and pulverulent, without taking fire on the coals. To these details we shall add, that the residue of ether affords new ether, by the addition of one-third of spirit of wine dephlegmated by salt of tartar, and distilling the mixture, as Mr. Cadet has shewn. These distillations may be repeated several times, and from a mixture of six pounds of oil of vitriol and spirit of wine, to which fifteen pounds of the latter

ter fluid are successively added, more than ten pounds of good ether may be obtained.

The operation we have described, is one of the most singular in chemistry for the phenomena it exhibits; and at the same time one of the most important, with respect to the explanation it affords concerning the composition of spirit of wine. There are two opinions respecting the formation of ether, which it is necessary to explain. Macquer, who, as we have observed, considers spirit of wine as a compound of water and phlogiston, thinks that the oil of vitriol takes the water from this substance, and causes it to approach gradually to the characters of oil. According to this opinion, therefore, spirit of wine first passes over scarcely altered; next a fluid, which occupies the middle place between water and oil; and lastly, a true oil, because the vitriolic acid acts so much the stronger on the principles of the spirit of wine, as the heat is more considerable. Bucquet made a strong objection to this theory; namely, that it is difficult to conceive, how the oil of vitriol, charged from the first with a certain quantity of water it had taken from the spirit of wine, could still, notwithstanding this dilution, re-act so strongly on a portion of the same spirit, as to put it into the oily state. He therefore proposed another opinion respecting the production

duction of ether. He considered spirit of wine as a fluid composed of oil, acid, and water; and imagined, that when the acid of vitriol is mixed with the spirit, a kind of bituminous fluid is produced, which affords by heat the same principles as all bitumens; namely, a light, odorous, very combustible oil, or a species of naphtha, which is the ether, and afterwards a less volatile and more coloured oil, which is the sweet oil of wine. We shall, in fact, perceive by the properties of ether, which we are about to explain, that this fluid has all the characters of a highly attenuated oil, such as naphtha. This theory does not explain, with sufficient perspicuity, what happens during the preparation of ether. The oxygenous principle appears to be taken from the vitriolic acid by the spirit of wine, and to be one of the principles of the ether.

Ether obtained by the process we have described, is not in a state of purity, but contains spirit of wine and sulphureous acid. It must be rectified by distillation in a retort, on a sand bath, with the addition of fixed alkali. The salt combines with the sulphureous acid, and the ether passes over in a state of great purity, by the gentlest heat. The first part of this product being received separate, is the purest and most highly rectified ether.

Ether is a fluid much lighter than spirit  
of

of wine, of a strong, sweet, and very expandible smell, of a hot and penetrating taste. It is so volatile, that it is instantly dissipated by agitation, or pouring out. During its evaporation, it produces a degree of cold sufficient to freeze water, as M. Baumé has shewn in his experiments. It takes the form of gas, which burns with great rapidity. Air, which holds ether in solution, may be passed through water without losing its smell and inflammability. Ether takes fire very readily when heated in the open air, or brought into contact with an inflamed substance. The electric spark likewise sets it on fire. Its flame is very luminous, and leaves a black coaly mark on substances exposed to it. M. Lavoisier has proved, that cretaceous acid is formed during the combustion of this liquor; and Mr. Scheele found that the residue of ether burned on a small quantity of water, contains vitriolic acid.

Ether dissolves in ten parts of water, according to the Count de Lauraguais. The phenomena produced by adding to ether all the saline substances, have not yet been examined; little more being known, than that the action of some acids, lime, and fixed alkalis, do not appear capable of changing it. The caustic volatile alkali mixes with it in all proportions, and forms a fluid, whose odour may be very useful in spasmodic disorders.



Oil of vitriol becomes much heated by mixture with ether, and converts a considerable part of it into sweet oil of wine by distillation. The fuming nitrous acid excites a considerable effervescence; the ether appearing to become more consistent, oily, and of a deeper colour in this experiment. Ether has not been combined with the other saline substances, nor even with the inflammable mineral substances. It is ascertained, that ether dissolves essential oils and resins, like spirit of wine; and ethereal tinctures are accordingly used in medicine.

Ether is considered as a powerful tonic, and anti-spasmodic remedy. It is used in hysterical disorders, and spasmodic cholics, and is of excellent service in cases where digestion is ill performed on account of weakness of the stomach. It must be administered, however, with prudence, because its excessive use is dangerous. It is likewise successfully applied externally in head-achs, burns, &c. Hoffman, who made many experiments with the vitriolic acid, and spirit of wine, used a medicine composed of sweet oil of wine dissolved in ardent spirit, which he called his mineral anodyne liquor. The Faculty of Medicine at Paris have added ether to this liquor, and prescribe it to be prepared by mixing two ounces of the spirit of wine which passes in distillation before the ether, two ounces of ether, and

and twelve drops of sweet oil of wine. This medicine is employed for the same purposes as ether, but is far from having the same efficacy.

The nitrous acid acts very strongly on spirit of wine. M. Navier is the first who described an easy and cheap method of preparing nitrous ether. He directs twelve ounces of very pure and well rectified spirit of wine to be poured into a very strong glass bottle, and plunged in cold water, or which is still better, in pounded ice : to this is to be added, in several portions, the liquor being agitated each time, eight ounces of spirit of nitre ; after which the bottle must be closed with a good cork, covered with leather, and well secured. This mixture is then to be left in a remote or private place, to prevent accidents that might arise from the bursting of the bottle, which sometimes happens. After some hours, bubbles arise from the bottom of the vessel, and are gradually collected at the top, forming a stratum of true ether. This disengagement continues from four to six days. As soon as the liquor appears to be at rest, the cork must be pierced with an instrument, that a certain quantity of air may escape, which, without this precaution, would rush out on opening the bottle, and carry the ether with it. As soon as the air is dissipated, the bottle is to be uncorked, and the fluid it contains poured into a funnel,

whose lower aperture being stopped with the finger, the residue may be separated from the ether which floats above, and must be kept in a separate vessel.

Mr. Woulfe describes another process for preparing nitrous ether. It consists in using very large vessels, that the disengaged air may have a considerable space to expand itself in. A matrafs of white glass, containing eight or ten pints, and terminated by a neck of seven or eight feet long, is placed on a tripod sufficiently high to admit of a chafing-dish being put underneath. To the neck of this matrafs, a tubulated head is adjusted, with a tube of seven or eight feet long adapted to its beak. The lower extremity of the tube is received in a vessel with two necks, whose lower part is drawn out into a tube, which is inserted in a bottle. To the other neck of this receiver is adapted the apparatus of bottles, which we have frequently mentioned as the invention of Mr. Woulfe. These vessels being well luted together, one pound of rectified spirit of wine, with an equal quantity of fuming spirit of nitre are poured into the matrafs, through the perforation in the head; this perforation is then closed with a ground stopper wrapped round with a piece of leather. As soon as the mixture is made, it becomes strongly heated, vapours are disengaged, which pass rapidly along the neck of the

the matrafs, and by applying a fufficient degree of heat to make the mixture boil, nitrous ether paffes into the receiver. This procefs, though very ingenious, has its inconveniencies. The adjustment of the apparatus is difficult, and the veffels are very expensive; befides which, the method is dangerous; becaufe, notwithstanding the fpace afforded to the vapours, they are difengaged with fo much rapidity, that the veffels frequently fly in pieces.

Mr. Bogues, in the year 1773, published another procefs for making nitrous ether. He directs one pound of fpirit of wine to be mixed with one pound of nitrous acid, weakened fo as to exhibit only twenty-four degrees of Beaumé's hydrometer, in a glafs retort, containing eight pints; to this a receiver of twelve pints is to be adapted, the air is fuffered to efcape by adjusting the barrels of two quills at the juncture of the lute, and the diftillation muft be performed by a very gentle heat. By this means he obtained fix ounces of nitrous ether, of confiderable purity. It appears, from the account of the Abbé Rozier, that Mr. Mitouard, as early as the year 1770, ufed a procefs nearly fimilar to that of Mr. Bogues. This chemift expofed four ounces of fuming fpirit of nitre with twelve ounces of fpirit of wine to diftillation in a retort, which he placed



lightly on the sand, and by this method, which appears the most simple of any, he obtained nitrous ether. Lastly, Mr. De la Planche, apothecary at Paris, has invented two methods of preparing nitrous ether very conveniently. The first consists in putting nitre into a tubulated stone-ware retort, to which a large receiver, with an adopter, is fitted; oil of vitriol is first poured to the nitre through the tube, and afterwards spirit of wine. The vitriolic acid disengages the spirit of nitre, which re-acts on the spirit of wine, and forms nitrous ether, almost immediately. As it might be suspected that the ether prepared in this way was partly vitriolic, he has substituted instead of this method, another, which is very ingenious. An adopter, and a receiver, which communicates, by a recurved tube, with an empty bottle, are affixed to a tubulated glass retort, containing six pounds of very dry nitre. The last vessel, namely the bottle, communicates by means of a syphon, with another bottle, containing three pounds of the purest spirit of wine. The whole being well luted, and the retort placed on a bath of ashes, three pounds of very pure oil of vitriol is poured on the nitre through the tube, which is immediately closed with a ground stopper. The mixture is then heated to ebullition, and kept in that state till no more vapours pass over. In this experiment, the

the vitriolic acid disengages the acid of nitre, which passes partly into the receiver, and partly into the second bottle. When the operation is ended, the receiver contains fuming spirit of nitre, the retort vitriolated tartar, and the second bottle an ethereal liquor. This last is distilled in a retort with a receiver, in the usual method, no more than two-thirds of the liquid being brought over. The product is again distilled with a fifth part of fuming spirit of nitre, poured in by a little at a time, through a glass funnel with a long neck; two-thirds of this liquid being likewise distilled over. Lastly, the second product is rectified by distillation from salt of tartar; the first four ounces being kept apart, and three-fourths of the remainder suffered to come over. The four ounces are very pure nitrous ether; the three-fourths of the remainder are a nitrous mineral anodyne liquor. The residues of the two rectifications are dulcified spirit of nitre.

Nitrous ether obtained by these processes, is a yellowish fluid, as volatile and evaporable as vitriolic ether, whose smell it resembles, though it is stronger, and not so agreeable; its taste likewise is hotter, and more pungent than that of vitriolic ether. It contains a small portion of superabundant acid. A large quantity of air is continually disengaged from it, which causes the stoppers

of the bottles containing it to fly out frequently. Its flame is brighter, and the smoke it emits when burned, is denser than that of the vitriolic ether; it leaves a larger coaly residue; and lastly, like the vitriolic ether, it takes gold from its solutions, and suspends a certain quantity.

The residue of nitrous ether is of a lemon yellow colour, its smell is acid and aromatic, and its taste is penetrating, and resembles that of distilled vinegar. It affords, by distillation, according to Baumé, a clear liquor of a milder taste than that of nitrous ether, being an agreeable acid, which reddens syrop of violets, unites with water in all proportions, and effervesces with cretaceous vegetable alkali. The retort contains a yellow friable matter, of the appearance of amber, which attracts the humidity of the air, becomes of a pitchy consistence, and is soluble in water without rendering it mucilaginous. This, which Mr. Baumé calls a gummy saponaceous substance, if the distillation be continued, affords a few drops of a very clear acidulous fluid, of an oily consistence, and slightly empyreumatic smell. A spongy, brilliant, tasteless, very fixed coal remains. Bucquet affirms, that if the liquor which remains after the formation of nitrous ether be evaporated, it assumes the consistence of a mucilage, and at the end of a certain time, affords saline crystals resembling

resembling hairy caterpillars, which have been called crystals of Hiærne, from the name of the chemist who first described them. It has since been discovered, that this residue is the acid of sugar, which proves that the combustible base of that acid is contained in spirit of wine.

The muriatic acid does not sensibly act on spirit of wine; this acid being only dulcified by simple mixture with the spirit, as are likewise the two others when mixed with a large proportion of spirit. Mr. Baumé, in his dissertation on ether, asserts, that he obtained a small quantity of marine ether, by causing spirit of salt and spirit of wine to meet in the form of vapour. Ludolf and Pott used butter of antimony with the same intention. Baron Born directs the solution of flowers of zink in the marine acid, and distillation of this salt concentrated by evaporation in close vessels, with spirit of wine. This process affords marine ether, with considerable facility. But no one has pursued this inquiry with so much diligence and success as the Marquis de Courtanvaux. According to the process of this chemist, a pint of spirit of wine is to be mixed in a retort with two pounds and a half of the smoking liquor of Libavius; a strong heat is excited, and a white suffocating vapour arises, which disappears when the mixture is agitated; an agreeable smell is then perceived, and the mixture assumes



assumes a lemon colour. The retort is to be placed on a hot sand bath, two receivers being luted on, the outer of which is plunged in cold water. A dephlegmated spirit of wine first passes over, and afterwards the ether rises, which may be perceived by its smell, and the striæ it forms in the neck of the retort. As soon as the smell changes, and becomes strong and suffocating, the receiver must be changed; a clear acid liquor then comes over, on the top of which float a few drops of sweet oil. This is succeeded by a yellow butyraceous matter, or true butter of tin; and lastly, a brown ponderous liquor, which emits abundance of white vapours. A grey pulverulent matter, or calx of tin, remains in the retort. The ethereal product being poured on oil of tartar in a retort, a strong effervescence takes place, and an abundant precipitate is thrown down, which is produced by the tin that came over in the distillation. A small quantity of water is then added, and a second distillation is performed by a gentle heat; the first half of the product being ethereal. All the fluids, which pass after the muriatic ether, are loaded with tin; they attract the humidity of the air, and unite with water, without affording any precipitate. It was formerly very difficult to determine the cause of the strong action of the muriatic acid contained in the fuming liquor on spirit of wine, since the pure acid does not at all  
act

act on that inflammable fluid. But, since the discovery of Mr. Scheele, it appears to be owing to the dephlogisticated or aerated state of the acid; and that its property of converting spirit of wine into ether must be attributed to the excess of the base of air it contains. This theory was first explained by me in the year 1781, and is now confirmed by the experiments of Messrs. Berthollet and Pelletier.

M. de la Planche, the apothecary, has proposed to make muriatic ether, by pouring oil of vitriol and spirit of wine on decrepitated marine salt, in a tubulated retort. The muriatic acid gas disengaged by the vitriolic acid, meets the vapour of spirit of wine in the receiver, and combines with it. An ethereal acid is produced, which may be purified by a second distillation from fixed alkali. In this process, the muriatic acid appears to take a portion of the oxygenous principle from the vitriolic acid.

Muriatic ether is very transparent; its smell is nearly the same as that of vitriolic ether; it likewise burns in the same manner, and affords a similar smoke. But it differs in two properties; the one, that when burning it exhales an odour as penetrating as the sulphureous acid; the other, that its taste is styptic like that of alum. These two phenomena shew, that this ether is different, and perhaps less perfect than the  
two

two foregoing; and there is no doubt but when its other properties shall be examined, other differences, equally remarkable, will be observed.

After having thus treated of the action of three mineral acids on spirit of wine, we shall resume the history of this fluid. The action of other acids on ardent spirit has been little examined. It is only known, that it readily unites with the acid of borax, or sedative salt, which communicates a green colour to its flame; and that it absorbs more than its bulk of cretaceous acid. As to the neutral salts, Macquer has determined, that vitriolic salts are not dissolved in this menstruum but with difficulty; that the nitrous and the muriatic salts unite with it much more readily; and that in general it dissolves saline substances with more facility in proportion as their acid is less adherent. Spirit of wine boiled on the vitriols of pot-ash and of soda, dissolved no part. Cretaceous vegetable alkali and soda do not unite with it, but most ammoniacal salts do. Deliquescent earthy salts, such as the combinations of lime and magnesia, either with the nitrous or marine acid, are perfectly dissolved. Some metallic salts are likewise very soluble, such as martial vitriol in the state of mother water, cupreous nitre, the muriates of iron and of copper, and corrosive sublimate; all the

the cupreous salts communicate a beautiful green colour to its flame. Mr. De Morveau has, since the time of Macquer, given a very accurate table of the degrees of solubility of salts by ardent spirit. This table is inserted in the *Journal de Physique*.

Spirit of wine does not dissolve sulphur either when in masses, or in powder; but these two bodies unite when they meet in the vaporous form, as the Count de Lauraguais has discovered. His process consists in putting flowers of sulphur into a glass cucurbit, upon which flowers he places a smaller vessel, filled with spirit of wine. A head and receiver being adapted, and the apparatus being heated by a sand bath, both substances rising together, combine and form a fluid, which passes into the receiver rather in a turbid state, and emits a fetid smell. It contains about one grain of sulphur in the drachm of spirit of wine. I have discovered that the same combination may be obtained by distilling hepatic waters, such as those of Enghien, with spirit of wine.

Ardent spirit has no action either on metallic substances, or their calces. It partly dissolves certain bitumens, such as amber and ambergris. It does not act on those which are black and coaly. It has been observed, that spirit of wine distilled from fixed alkalis, acts more strongly on these bitumens, and that a mixture of alkali with  
these



these renders them more soluble ; doubtless, by converting them into a kind of soap.

There are few vegetable matters on which spirit of wine does not act more or less. Extracts lose their colouring part, and when they are of the refinno-extractive, or extracto-refinous kind, great part is dissolved. Saccharine and saponaceous juices also unite with this fluid. Margraaf, by means of ardent spirit, obtained a saccharine essential salt from beet root, skirwort, parsnips, &c. But the matters with which it combines the most readily, are the essential oils, spiritus rector, camphor, balsams, and resins. The name of spirituous distilled waters is given to spirit of wine impregnated with the spiritus rector of plants. These fluids are obtained by distillation from odoriferous plants with spirit of wine. The spirit seizes the principle of smell, and rises with it, carrying up at the same time a certain quantity of essential oil, which causes it to become white by the addition of distilled water ; but this principle may be separated by rectification on a water-bath, with a very gentle heat, care being taken to draw off no more than three-fourths of the spirit, in order to be certain of having only the spiritus rector. These spirituous distilled waters acquire a more agreeable smell by keeping ; the odorous principle appearing to combine more intimately with the spirit.

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The spiritus rector has so strong an affinity with spirits of wine, that this fluid takes it from essential oils and water. In fact, when spirit of wine is distilled from essential oils, or from water charged with the smell of a plant, it takes the odorous principle, and leaves the oil or water without smell. It is observed, that spirit of wine dissolves the ponderous and thick essential oils more perfectly than those which are fluid and light. Water separates this compound by precipitating the oil in the form of white opake globules; but the spiritus rector remains united to the spirit of wine. Spirit of wine readily dissolves camphor in the cold, but it dissolves a larger quantity by the assistance of heat. This solution, when well saturated, as for example, two drachms of camphor to one ounce of spirit of wine, being diluted with water, added drop by drop, affords a crystalline vegetation observed by Mr. Romieu. It consists of a perpendicular stem, into which fibres are inserted, forming an angle of 60 degrees with the perpendicular stem. This experiment seldom succeeds, and requires many trials to ascertain the quantity of water, the degree of cooling, &c.

The names of tinctures, elixirs, balsams, quintescences, &c. are given to compounds of oily or resinous juices in spirit of wine, which is sufficiently charged to have a high colour,

colour, and to afford an abundant precipitate by water. Like distilled water, they are distinguished by the denomination of simple, when they contain but one substance in solution; or compound, when they contain many. These medicines are, in general, prepared by exposing the dry vegetable itself, whose essential oil or resin is required to be extracted, or the pulverized extract of the plant, to the action of spirit of wine, which is assisted either by agitation, or the heat of the sun, or a sand bath. When the resins of a number of plants, or vegetable substances, are required to be dissolved in the same spirit, care must be taken to digest that substance first, which is the most difficultly acted on by the spirit; and to add the other substances in the order of their solubility. When the menstruum has exhausted its action, and is saturated, it is to be strained off. A compound tincture is sometimes extemporaneously made, by mixing several simple tinctures. Thus the elixir proprietatis is made, by mixing the tinctures of myrrh, saffron, and aloes. Resins and balsams may be separated from spirit of wine by the affusion of water, or by distillation; but in either case, the spirit retains the odorous principle.

Water is not capable of decomposing tinctures formed with the extracto-resinous, or resino-extractive substances, such as the  
tincture

tincture of rhubarb, saffron, opium, gum ammoniac, &c. ; because these substances are equally soluble in both menstrua.

Spirit of wine and brandy are of the most extensive use: the latter is drank with the intention of recruiting the animal forces; but it is dangerous if excessively used, because it dries the fibres, and produces tremblings, palsies, obstructions, dropies, and other disorders. Spirit of wine, either pure, or with the addition of camphor, is used to stop the progress of gangrenes.

Spirituos distilled waters are administered in medicine, as tonic, cordial, antispasmodic, stomachic, &c. They are given either diluted in water, or softened by the addition of syrup.

The drinks called ratafias, or cordials, are made with these distilled waters and sugar. When they are well prepared, and taken in small quantities, they may be useful; but in general, they can be of service only to few, and may produce bad consequences to most who take them. The excessive use of this kind of liquors is truly dangerous, for instead of strengthening the stomach, they in general produce the contrary effect. Those which are the least pernicious, when occasionally taken with moderation, may be prepared without heat, by infusing the aromatic substance in one part of rectified



spirit of wine, with two parts water, and one of fine sugar.

Tinctures have nearly the same virtues as the spirituous distilled waters, but their action is much stronger; for which reason they are used in small doses in pills, or with wine, or water. The precipitates they form in this last case, are suspended for a sufficient time in the mixture, and the odorous part remains dissolved in the spirit of the tincture.

Lastly, spirit of wine united to copal, oil of aspic, or of the greater lavender, or to oil of turpentine, forms varnishes which are called drying; because, when applied on any substance, the spirit of wine evaporates, and leaves a transparent resinous coating. A mixture of essential oil prevents these varnishes from drying too quickly, and communicates a degree of unctuousity, which renders them less brittle.

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## C H A P. XXII.

### Concerning Tartar.

**T**ARTAR is an essential salt, united to a portion of vegetable fixed alkali and oil. It is deposited on the sides of casks during the insensible fermentation of wine.

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It is not produced by the spirituous fermentation, as some chemists have supposed; for Rouelle the younger discovered it ready formed in unfermented wine, or must, and in verjuice.

It has the form of irregular plates, disposed in strata, often full of brilliant crystals, and of a vinous acid taste. It is distinguished into white tartar, and red tartar, the latter differing from the former only in a greater abundance of colouring matter.

Crude tartar exposed to heat in close vessels, affords a reddish acid phlegm, an oil at first light, and afterwards ponderous, coloured, and empyreumatic; a small quantity of volatile alkali, and much cretaceous acid, which Hales, Boerhaave, and many other chemists supposed to be air. A coal remains, which contains a large quantity of cretaceous vegetable alkali, and is easily burned. Vegetable alkali, of considerable purity, is obtained by the combustion and incineration of tartar.

With this intention, pulverized tartar is wrapped up in papers, which are afterwards dipped in water; these are ranged in a furnace, between two strata of charcoal, which being set on fire, the tartar burns, and is calcined; when the fire is burnt out, the papers of tartar are found in their original form; these are lixiviated with cold distilled water, which after filtration is evaporated

to a pellicle, and suffered to cool, in order to separate the vitriolated tartar, which crystallizes by repose. The fluid solution being decanted off, is evaporated and crystallized a second time; and this process is repeated as long as any crystals are afforded: after which it is evaporated to dryness, and affords vegetable alkali, partly caustic, and partly combined with cretaceous acid.

Tartar is but sparingly soluble in water: one ounce of that fluid, at the temperature of 55 degrees of Fahrenheit, dissolved no more than four grains. As it contains a large quantity of oleaginous colouring matter, it is purified by solution and crystallization, at Aniane and Calvisson, in the neighbourhood of Montpellier. Dr. Fizes has given a full description of this purification, in a memoir printed among those of the Academy in 1725.

The tartar is boiled in water, and filtered while hot; the solution becomes turbid on cooling, and deposits irregular crystals, which form a paste; the paste is boiled in copper vessels, together with water, mixed with an argillaceous earth, brought from Merviel, two leagues from Montpellier. A scum rises to the top, which is carefully taken off, and is at length succeeded by a saline pellicle. The fire is then put out; and the pellicle being broken, falls to the bottom, among the crystals which precipitated from the solution. The earth, which fouls these crystals, is washed

washed off with cold water, and they are then sold, under the name of cream of tartar, or crystals of tartar; which differ only in the circumstance, that the cream is formed at the surface, while the crystals are deposited at the bottom of the liquor. The white clay appears to deprive the tartar of its superabundant oily and extractive matter.

Tartar according to M. Desmaretz, is, purified in a somewhat different manner at Venice. The pulverized salt, being dissolved in boiling water, deposits its impurities, from which it is carefully separated, and the liquor affords crystals by cooling. These crystals are re-dissolved in water, gradually heated; and as soon as it boils, beaten whites of eggs, with sifted wood ashes, are thrown in. This mixture of ashes is made fourteen or fifteen times; the scum is taken off, and the liquor left to cool. A pellicle of very white saline crystals is soon formed, which after the water is decanted, are suffered to dry. This method changes the nature of the cream of tartar, by converting a part into tartarized vegetable alkali. We shall proceed to examine the chemical properties of cream of tartar, or tartar purified in the neighbourhood of Montpellier.

Very pure cream of tartar is crystallized, though irregularly; it has an acid taste, less viscid than that of crude tartar. On hot coals, it emits much smoke, of a penetrating empy-



reumatic smell, and itself becomes black and carbonaceous. If cream of tartar be distilled in an earthen retort, with a receiver, connected with an inverted vessel of water, by means of a tube, and the fire be gradually raised, a phlegm, almost colourless, and scarcely acid, first comes over; next a stronger acid, of a deeper colour; and afterwards an oil, which becomes more and more coloured, consistent, and empyreumatic; and last of all, the concrete volatile alkali, and a large quantity of cretaceous acid. A very abundant coal remains in the retort, which, lixiviated without incineration, affords a large quantity of fixed alkali. The distilled products may be rectified by a gentle heat. In this rectification, the phlegm passes over nearly colourless, the oil becomes very white and volatile, the volatile alkali partly combines with the acid, and is not obtained separate and pure, but by distilling the last portions of phlegm with the addition of fixed alkali. The vegetable fixed alkali, contained in the coal, is not produced in the operation, as many chemists have thought, but is all contained originally in the tartar. The re-action of the fixed alkali on the oil produces the volatile alkali; and the quantity of volatile salt may be increased, by distilling the oil obtained from the cream of tartar a second time, with the coal it leaves in the retort.

Cream

Cream of tartar is not altered by exposure to air.

It dissolves in twenty-eight parts of boiling water, and crystallizes confusedly by cooling, as we have observed. A certain quantity of earth separates from the solution of this salt, which is doubtless that which was used in its purification: the solution reddens tincture of turnsole, and has an acid taste.

The action of quartzose earth, clay, and ponderous earth, or barytes, on cream of tartar, is not known. The chemists of the academy of Dijon have observed, that magnesia forms, with cream of tartar, a soluble salt, decomposable by fixed alkali, and affording, by evaporation in the open air, small prismatic crystals in radii. This tartar of magnesia boils up, and becomes converted into a light coal, by exposure to the action of fire. M. Poulletier de la Salle obtained from this combination a gelatinous mass, perfectly resembling mucilage.

The action of lime, and of chalk, on cream of tartar, has been well described by several chemists. When chalk is thrown into a solution of cream of tartar, an effervescence is produced, occasioned by the disengagement of cretaceous acid; and a very abundant precipitate, consisting of a combination of the tartareous acid and lime, is formed. The supernatant liquor contains a neutral salt,

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which

which existed, ready formed, in the cream of tartar, and consists of the acid of tartar, united to vegetable alkali: it is known, as we shall presently see, by the name of soluble tartar. We are indebted to Rouelle the younger for this valuable analysis of cream of tartar; which proves, 1. That this substance is composed of a superabundant oily acid, and a certain quantity of this acid, united to vegetable fixed alkali, in the state of a neutral salt. 2. That the combination of the tartareous acid with lime, forms a neutral salt of very difficult solubility. Mr. Proust has discovered, that calcareous tartar, distilled in a retort, leaves a residue, which takes fire by exposure to air, like pyrophorus. Bergman, in his dissertation on the elective affinities, gives a process for separating the tartareous acid. He directs the precipitate formed by chalk thrown into a solution of cream of tartar, to be washed with distilled water; this tartarized lime being then put into a phial, eight times its weight of vitriolic acid, consisting of one part of oil of vitriol, and eight water, must be poured thereon. After digesting for twelve hours, and being frequently stirred with a spatula of wood, the clear liquor must be decanted off from the mixture; the deposition at the bottom must likewise be washed with water, till it no longer communicates any taste; and the water used in washing

washing is to be added to the former liquid. This is the tartareous acid. It is evident, in this experiment, that the vitriolic acid decomposes the calcareous tartar, and forms selenite, at the same time that it disengages the tartareous acid, which remains dissolved in the water. The acid thus obtained almost always contains a small quantity of vitriolic acid, which may be precipitated by the addition of a small quantity of calcareous tartar, the earth falling down with the vitriolic acid, in the form of selenite, while the tartareous acid is disengaged. Bergman adds, that the solution of this acid, evaporated to the consistence of syrup, affords crystals, in plates or scales; that these crystals become black by heat, and afford, by distillation, an acidulous phlegm, with a small quantity of oil; leaving a residual coal, which is neither acid nor alkaline. Hence it appears, that the tartareous acid contains oil, like all the other acids of vegetables.

Cream of tartar unites very well with the different alkalis. If it be added to a solution of cretaceous vegetable alkali, a strong effervescence is immediately produced, by the disengagement of the cretaceous acid. The cream of tartar must be added to saturation, and the liquor filtered, after having boiled for half an hour; after which, the evaporation being continued till a pellicle is formed, the solution, by slowly cooling, affords



affords long quadrangular prisms, terminated by two facets, placed slantwise. This salt is known by the names of vegetable salt, soluble tartar, tartarized tartar, and ought to be called tartar of pot-ash. It has a bitter taste; is converted into a coal by a strong heat; and is decomposed by distillation, affording an acid phlegm, oil, and a large quantity of cretaceous acid. It slightly attracts the humidity of the air, and is completely dissolved in four parts of water, at the heat of 120 degrees. The mineral acids decompose it, and precipitate cream of tartar; it is also decomposed by most metallic solutions.

Cream of tartar, combined with soda, forms salt of Seignette, so called from the name of an apothecary of Rochelle, who first composed it. It is prepared, by dissolving twenty ounces of cream of tartar in four pounds of water, and gradually adding very pure crystallized vegetable alkali to saturation, which point is known by an effervescence not being excited by the addition of more alkali. In this combination the cream of tartar is rendered more soluble. The fluid being evaporated, till it has nearly the consistence of syrup, affords, by cooling, very beautiful regular crystals, often of a considerable magnitude. They are prisms of six, eight, or ten unequal faces, truncated at right angles at their extremities. These prisms are most commonly bisected lengthwise; and the

the large face, or base, on which they rest, is marked by two diagonal lines, intersecting each other, and dividing the base into four triangles. The salt of Seignette, which ought to be called tartar of soda, was at first sold as a secret, but was discovered, at the same time, by Boulduc and Geoffroy, in 1731. It has a bitter taste; is decomposed by the fire, like the tartar of pot-ash; effloresces in the air, because it contains much water of crystallization, and is nearly as soluble as tartar of pot-ash, and, like that salt, is decomposed by mineral acids and metallic solutions. The mother water of this salt, contains the portion of tartar of pot-ash, which composes part of the cream of tartar.

The volatile alkali forms, with cream of tartar, an ammoniacal tartareous salt, which crystallizes very well by evaporation and cooling. Bucquet affirms, that its crystals are rhomboidal pyramids. Macquer observed some, in thick prisms, of four, five, or six sides; others thickest in the middle, and terminated by very acute points. The academicians of Dijon obtained them in oblique angled parallelopipedons. Ammoniacal tartar has a cool taste, and is decomposed by heat: in the air it effloresces: hot water dissolves it more readily than cold; and it crystallizes by cooling. Lime and fixed  
alkalis

alkalis disengage the volatile alkali; mineral acids and metallic solutions decompose it.

Pott and Margraaf treated cream of tartar with the mineral acids, and the latter obtained neutral salts, similar to those afforded by each of these acids with vegetable alkali; whence he concluded, that this alkali exists, ready formed, in cream of tartar. Rouelle the younger made a number of accurate experiments, which afforded the same results. A pound of cream of tartar, in very fine powder, was added to a pound of oil of vitriol; the mixture became hot, and the mutual action of the two substances on each other was assisted by the heat of a water-bath, and by frequent stirring with a glass instrument. This heat being continued ten or twelve hours, the mixture became of the thickness of cream, at which period two or three ounces of boiling distilled water were added, which rendered the whole fluid. Two hours after, the mixture was taken from the fire, and three pints of boiling distilled water were added. This solution was coloured, and opaque, and contained disengaged vitriolic acid, a portion of cream of tartar not decomposed, and vitriol of pot-ash. The excess of vitriolic acid was then saturated with chalk; and selenite, with a small quantity of cream of tartar, were precipitated. The mixture was then filtered and evaporated, till it became reduced to eighteen or twenty ounces;

ounces; during which, a small quantity of cream of tartar and of selenite, fell down. The fluid was decanted off, evaporated a second time, and by standing afforded vitriolated tartar; more of which was obtained in the like manner by successive evaporations. This salt is always mixed with a small quantity of cream of tartar, and burns on a hot iron. But if a due quantity of distilled water be added, the vitriolated tartar will be taken up, and the cream of tartar will remain undissolved. The foregoing process is described by Berniard, who repeated it with success after Rouelle.

The nitrous and muriatic acids, treated in the same manner with cream of tartar, afford nitre and febrifuge salt; which incontrovertibly proves the existence of vegetable alkali in this substance.

Cream of tartar acquires solubility, by uniting with borax and sedative salt. According to the experiments of M. De Laffone, one part of the latter salt may render about four parts of cream of tartar soluble. This mixed solution affords a greenish, very acid gummy salt, by evaporation.

Cream of tartar appears capable of uniting with most metallic substances, as Messrs. Monnet and the chemists of the academy of Dijon have shewn. But as these combinations have been little examined, we shall only speak, in this place, of those of antimony,



mony, mercury, lead, and iron; because they are better known, and are most of them used in medicine.

The combination of cream of tartar and antimony, is called stibiata, or antimoniated tartar, or more commonly emetic tartar. As it is one of the most important remedies afforded by chemistry, it is necessary to examine its properties with the greatest care. Since the time of Adrian de Mynsicht, who first described this composition, in the year 1631, the process for making it has been greatly varied. The Pharmacopeia, and the writings of chemists, all differ, either in the antimonial substances directed to be employed, as well as in the cream of tartar and water, either with respect to quantity, or the method of applying them to each other. Bergman, in his dissertation on this medicine,\* has given an excellent section on the different processes heretofore used in preparing antimoniated tartar. The crocus metallorum, the liver, the glass, and the flowers of antimony, have been successively prescribed: some direct these substances to be boiled with cream of tartar, and a greater or less quantity of water, for ten or twelve hours; others direct the ebullition to be continued no longer than half an hour; others again require the filtrated lixivium to be evaporated

\* Essays, Vol. I.

to dryness; and lastly, there are others who direct it to be crystallized, and the crystals only to be used in medicine. Hence it happens, that antimoniated tartar is never the same substance, but possesses various degrees of force, so that its effects cannot be clearly ascertained. And accordingly Geoffroy, who examined many specimens of antimoniated tartar, of different degrees of force, found, by the analysis, that the weakest contained from thirty to ninety grains of regulus, in the French ounce of 576 grains. Those of a middle degree of emetic power, 108 grains, and the strongest 154 grains. Glass antimony has been chosen in preference to other antimonial substances, because it is one of the most soluble by cream of tartar; but this glass may be more or less calcined, and the different degrees of calcination must affect its emetic power. However, if very transparent glass of antimony, previously well levigated, be boiled in water, with an equal weight of cream of tartar, till the latter is saturated, and this solution be filtered and evaporated by a gentle heat, crystals of antimoniated tartar are obtained, by standing, whose emetic power appears to be sufficiently constant. The liquor being decanted and evaporated, affords new crystals for several successive times. The mother water contains sulphur, tartar of pot-ash, and a certain quantity of liver of sulphur. When the mixture of cream of tartar, glass  
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of antimony, and water, which has been boiled for the preparation of antimoniated tartar, is passed through the filtre, a yellow or brown gelatinous substance remains behind, which Rouelle has examined, and finds to afford, by distillation, a very inflammable pyrophorus.

Macquer proposes to substitute the powder of algaroth, instead of glass of antimony, in the preparation of emetic tartar; because this powder is itself a violent emetic, and when precipitated from the butter of antimony is always the same. Bergman has adopted the opinion of Macquer; and since that time, emetic tartar has been prepared in the laboratory of the academy of Dijon according to the method of Bergman and M. De Laffone. This medicine has been used with the greatest success: it operates, in a dose of three grains, without fatiguing the stomach or intestines.

Antimoniated tartar crystallizes in very transparent trihedral pyramids, decomposable by heat, which converts them to a coaly substance. It effloresces in the air, and becomes a white farinaceous powder; it is soluble in sixty parts of cold water, or in a much less quantity of hot water. It crystallizes by cooling; and is decomposed by lime and alkalis. Calcareous earth, and pure water, in a large dose, are capable of decomposing it; whence it follows, that it ought to be administered only in distilled water. Liver of sulphur, and hepatic

hepatic gas, precipitate from it a red powder, or kind of golden sulphur, which may serve as a test for the presence of this salt in all liquors containing it. Iron seizes the acid of tartar, and separates the calx of antimony; antimoniated tartar ought not, therefore, to be prepared in vessels of this metal. Mr. Durande, physician and professor at Dijon, proposes that this medicine be made publickly, and by one uniform process, established by law, as the theriaca is made; and we are convinced, that the greatest advantages would arise to the practice of physick from such a regulation being adopted.

The tartareous acid may be combined with mercury by two methods. The one mentioned by Mr. Monnet, consists in dissolving six parts of cream of tartar in boiling water, with one part of mercury, precipitated from the nitrous acid by cretaceous vegetable alkali. This liquor, filtered and evaporated, affords crystals, that are decomposable by pure water. The second method of uniting mercury with the tartareous acid, consists in pouring a nitrous solution of this metal into a solution of tartar of pot-ash, or tartar of soda: a precipitate of mercurial tartar is afforded, and the nitre of pot-ash, or soda, remains dissolved in the liquor.

Cream of tartar has a sensible action on the calces of lead. Rouelle the younger has ascertained, that the saturnine tartar, pro-



duced in this operation, does not remain dissolved, but that the liquor, by evaporation, affords pure vegetable alkali, which was ready formed in the cream of tartar. This is one of the processes he has made use of to prove that fixed alkali exists in tartar.

Copper, and its calces, are readily attacked by the tartareous acid : the result is a salt, of a beautiful green, capable of crystallization, but hitherto little examined.

Iron is very strongly acted on by cream of tartar. A medicine, called chalybeated tartar, is prepared, by boiling eleven ounces of levigated iron filings with one pound of white tartar, in twelve pounds of water. When the tartar is dissolved, the liquor is filtered, and deposits crystals, more of which may be obtained by subsequent evaporation. To prepare the tartarized tincture of Mars, a paste is made, with six ounces of iron filings, one pound of white tartar in powder, and a sufficient quantity of water. This mixture is left at rest for twenty-four hours ; after which twelve pounds of water are added, and the whole boiled for two hours ; fresh water being added in proportion as the evaporation goes forward. The liquor is then decanted, filtered, and thickened, by boiling to the consistence of syrup ; after which one ounce of spirit of wine is added. Rouelle ascertained, that the fixed vegetable alkali exists at liberty in this tincture, and that by heating

heating it with acids, neutral salts, with base of this alkali, are obtained. There are likewise two other medical preparations, formed by the combination of the tartareous acid and iron. The one is soluble martial tartar, consisting of one pound of the tartarized tincture of Mars, and four ounces of tartar of pot-ash, evaporated to dryness. The other is known by the name of martial balls. They are made by mixing, in a glass vessel, one part of steel filings, and two parts of white tartar in powder, with a certain quantity of brandy; when the brandy is evaporated, the mass is pulverized, and more brandy added, which is suffered to evaporate as before. This process is repeated till the mass becomes tenacious, when it is formed into balls.

Crude tartar is very useful in the art of dying, and it is likewise made use of by hat-makers.

The different preparations of cream of tartar which we have enumerated, are mostly used in medicine; pure cream of tartar is considered as cooling and antiseptic. In the dose of half an ounce, or an ounce, it purges gently, and without exciting nausea. The tartars of pot-ash and of soda are often used, in conjunction with other purgative medicines, in the dose of a few drachms: antimoniated tartar is one of the most useful and efficacious medicines afforded by chemistry. This salt is emetic, purgative, diuretic, diaphoretic,

retic, or deobstruent, according to the doses and processes used in administering it. It often produces all these effects at one time. It may also be considered as a powerful alterative, of excellent use in removing obstructions of the viscera, when given in small doses often repeated. It is administered as an emetic, in the dose of from one to four grains, dissolved in water. It is mixed, in the dose of a grain, with other purgatives, whose action it assists: and lastly, when given in the quantity of half a grain, greatly diluted with water, it acts as an alterative. M. De Lassone has discovered, that antimoniated tartar is rendered very soluble in water by the mixture of sal ammoniac; and that a mixed salt, similar to sal alembroth, is produced. It may be concluded, that this new compound is capable of producing considerable effects on the animal economy.

Chalybeated tartar, soluble martial tartar, and the tartarized tincture of Mars, are used as tonic and aperient medicines.

## CHAP.

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C H A P. XXIII.

## Of the Acid Fermentation, and of Vinegar.

**M**ANY vegetable substances, such as gums and amylaceous fecula, dissolved in boiling water, are capable of undergoing the acid fermentation; but this property is more especially remarkable in fermented and spirituous liquors. All these fluids, when exposed to heat in contact with air, undergo the acid fermentation, and afford the liquor called vinegar. The wine of grapes is more especially used in preparing this liquor, though it is possible to make very good vinegar with cyder, perry, &c.\*

There are three conditions necessary to the acetous fermentation: 1. A degree of heat from 75° to 90° of Fahrenheit. 2. A substance at the same time viscous and acid, such as mucilage and tartar. 3. The contact of air. The change which wine undergoes, when it becomes converted into vinegar, must be attributed to an intestine motion, excited in the fluids by the presence of a certain quantity of

\* Vinegar is made in Britain from wort, which is the infusion of malt, made in the same way as in the process of brewing. T.



mucilage, which is not changed, and is capable of passing through a new fermentation. The presence of an acid substance, such as tartar, is necessary to determine the acid fermentation. Lastly, the contact of air is indisputably necessary, and it appears that a certain portion is absorbed during this fermentation, as the Abbé Rozier has proved.

All wines are capable of forming vinegar. The bad wines are employed in preference, for the sake of cheapness; but the experiments of Beccher and Cartheuser, prove, that generous wines, abounding with ardent spirit, afford in general the best vinegar.

Boerhaave, in his Elements of Chemistry, has described a very good process for making vinegar. Two large casks are provided, and a false bottom of wicker is fixed, at some distance from the bottom, within each, on which vine branches and grape stalks are spread: wine is then poured in; so that one of the vessels is filled, and the other only half full. The fermentation commences in the latter: when it is well established, it is filled up with wine added from the other tun. By this means, the fermentation is retarded in the full vessel, and accelerated in the other. When it has arrived at a considerable degree in this last, it is again filled up, by transferring part of the fluid from the other; the fermentation consequently recommences  
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in the vessel from which the liquor was last taken, and becomes slower in that which is filled up. The alternate filling and emptying of the vessels is continued till the vinegar is perfectly formed, which usually happens in twelve or fifteen days.

When the effects of this fermentation are attend to, much ebullition and hissing is perceived; the liquor becomes hot and turbid, exhibits a great quantity of filaments and bubbles, agitated in every direction; a strong acid smell, not at all dangerous, is emitted, and a large quantity of air is absorbed. It is necessary to impede the fermentation every twelve hours. These phenomena gradually become less, the heat decreases, the motion decays, and the fluid recovers its transparency: a sediment is deposited, in reddish flocks, which adhere to the sides of the vessels. Numerous experiments have shewn, that the smaller the quantity of wine, and the more perfect the access of air, so much the more readily does it pass to the state of vinegar. The vinegar must be carefully drawn off, in order to separate it from its lees, which, without this precaution, would quickly cause it to undergo the putrid fermentation. Vinegar does not deposit tartar by standing, like wine; this salt is dissolved, and combined with the ardent spirit and water during the fermentation. It is

even probable, that the presence of this salt contributes to the taste and other acid properties of vinegar. This fluid has more or less of colour, according to that of the wine used in its preparation; but in general, vinegars, which have the least colour, are far from being of as light a colour as the white wines, because they hold in solution the colouring matter of the tartar, which has likewise been developed by the production of the acid.

Vinegar, prepared in the method here described, is very fluid; of an acid and spirituous smell; and of a sour taste, of different degrees of strength: it reddens blue vegetable colours. When exposed to a warm temperature, in imperfectly closed vessels, it becomes changed, losing its spirituous part, and depositing a great quantity of mucilaginous flocks and filaments, at the same time that it assumes a putrid smell and taste. In order to preserve it, it is necessary to boil it for a short time, as Scheele has observed.\*

When vinegar is distilled by a naked fire, in an earthen alembic, or in a glass retort, on a sand-bath, a phlegm, of a lively and agreeable smell, but scarcely acid, first passes over; this is succeeded by a very white and odorous liquor, called distilled vinegar. The following products have less smell, and more acidity, as the distillation advances. If these

\* This discovery, announced in Scheele's Essays, p. 315, English translation, did not succeed with me upon trial. T.

products be taken separately, distilled vinegars, differing from each other in acidity and smell, may be obtained; but it is usual, in this process, to draw off about two-thirds of the liquor, which constitutes the purest vinegar. The portion which comes over afterwards is more acid, but it has an empyreumatic smell, which may be dissipated by exposure to air; it is likewise slightly coloured. This operation shews, that the acetous acid is less volatile than water. The remaining vinegar is thick, of a deep and dirty colour, deposits a certain quantity of tartar, and is considerably acid. If it be evaporated in open vessels, it takes the form of an extract; and if, when dried, it be distilled in a retort, it affords a reddish phlegm, acid, an oil at first light coloured and afterwards heavy, with a small quantity of volatile alkali. The remaining coal contains much fixed alkali.

Vinegar may be concentrated by exposing it to frost. The frozen part consists almost intirely of water; the part which remains fluid, being decanted off, is found to be much more acid: the quantity of vinegar thus obtained is small.

The acid of vinegar, separated from tartar and the colouring matter, by distillation, is capable of uniting with a great number of bodies.

It does not readily combine with argillaceous earth, with which it forms crystals,  
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in small needles, whose properties are little known. It is the acetous salt of clay.

This acid unites readily with magnesia, and affords a salt, which is very soluble in water, and does not afford crystals, but is converted into a viscous deliquescent mass, by evaporation. The acetous salt of magnesia is decomposed by fire, by the mineral acids, by ponderous earth, by lime, and by the alkalis. It is very soluble in spirit of wine.

The acid of vinegar combines with lime, and decomposes chalk, whose acid it disengages, in the form of an elastic fluid. The salt it forms with lime, crystallizes in very small prisms, of a fatty appearance. The calcareous acetous salt is bitter, and sour, and effloresces in the air. Fire decomposes it; its earth is separated by fixed alkalis; and the mineral acids disengage its acid.

The combination of the acid of vinegar with vegetable alkali, is called *terra foliata tartari*, and ought to be called, the acetous salt of pot-ash. This salt is prepared, by pouring very pure distilled vinegar on white salt of tartar; the mixture is agitated, and the vinegar added, till the saturation is perfect, and the salt well dissolved. It is proper to add an excess of acid. The liquor, being first filtered, is evaporated, by a gentle heat, in a vessel of porcelain, or pure silver; and when it becomes thick, the evaporation is continued.

nued to dryness, on a water-bath. By this means, a very white terra foliata is obtained. If too strong a degree of heat be used, it becomes grey, or brown, by the burning of a portion of the vinegar. Some chemists affirm, that this salt may be obtained in a regular form, by cooling the solution previously evaporated to a thick pellicle. The acetous salt of pot-ash has a penetrating, acid, and urinous taste. It is decomposed by the action of fire; and affords, by distillation in a retort, an acid phlegm, empyreumatic oil, volatile alkali, and a large quantity of strong-smelling gas, consisting of a mixture of cretaceous and inflammable gas. The residual charcoal contains much disengaged fixed alkali. This salt strongly attracts the humidity of the air, and is very soluble in water. The vitriolic acid decomposes it. For this purpose, one part of oil of vitriol is poured on two parts of the acetous salt of pot-ash, introduced into a tubulated retort, to which a receiver is adapted: a vaporous fluid, of a penetrating smell, is immediately disengaged, with a strong effervescence, which condenses in the receiver, into a liquor called radical vinegar. This vinegar is very concentrated, and strongly acid; but it is not pure, as it always contains a certain quantity of sulphureous acid, distinguishable by its smell. Cream of tartar likewise decomposes the acetous salt of pot-ash, because it has a stronger affinity

affinity than the acetous acid with the alkaline base of this salt.

Vinegar unites perfectly with soda, and forms a salt, improperly called crystallizable terra foliata. This does not differ from the acetous salt of pot-ash, but in its crystallizing in striated prisms, resembling those of the vitriol of soda, and in its not attracting the humidity of the air. To obtain perfect crystals, the solution must be evaporated to a pellicle, and set in a cool place. The acetous salt of soda is decomposed by fire, and the mineral acids; and we may observe, that if the calcareous, or alkaline acetous salts, be distilled by a strong heat, the residues are pyrophori, which take fire when exposed to the air. Mr. Proust, the discoverer of these facts, is of opinion, that a pyrophorus is produced in all cases, where a carbonaceous residue is divided by an earth or a metallic calx.

The acid of vinegar, with the volatile alkali, forms a liquor, known by the name of spirit of Mindererus. This salt is so volatile, that it cannot be evaporated without losing the greatest part of it. Nevertheless, crystals, in the form of needles, and of a hot and penetrating taste, may be obtained by slow evaporation. The ammoniacal acetous salt is decomposed by the action of fire, by lime and fixed alkalis, which disengage the volatile

volatile alkali, and by the mineral acids, separate the vinegar.

Vinegar acts on almost all metallic substances, and its combinations are attended with a variety of important phenomena.

It does not appear to dissolve the calx of arsenic; but this last substance distilled with an equal part of the acetous salt of pot-ash, afforded Messrs. Cadet, and the chemists of the Academy of Dijon, a red fuming liquor of a nauseous smell, very tenacious, and of a singular nature. Mr. Cadet had before observed, that this liquor inflames fat lute. The academicians of Dijon being desirous of examining a yellowish matter of an oily consistence, collected at the bottom of the vessel, which contained the arsenico-acetous, fuming liquor, decanted a portion of this superfluent liquor, and poured the rest on a filter of paper. A few drops had scarcely passed, when immediately an offensive and very thick fume arose, which formed a column from the vessel to the ceiling; a kind of ebullition was excited on the borders of the matter, and a beautiful rose-coloured flame issued forth; all which lasted a few seconds. A full account of the experiments of these learned Academicians, may be seen in the third volume of the Elements of Chemistry of Dijon. They compared the liquor we have spoken of to a liquid phosphorus; we think it is a pyrophorus of the  
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the same kind as those we shall presently mention. The residue of the distillation of the acetous salt of pot-ash with calx of arsenic, consists for the most part of vegetable fixed alkali.

Vinegar dissolves the calx of cobalt, and forms a solution of a pale rose colour.

It has no action on bismuth, or its calces.

It dissolves nickel directly, according to Mr. Arvidson; this solution affords green crystals, of the form of a spatula.

The acetous acid does not appear to act on the regulus of antimony, but it appears to dissolve the glass of this semi-metal; since Angelus Sala made an emetic preparation with these two substances.

Zink, and also its calces, are readily dissolved by vinegar. Mr. Monnet obtained crystals from this solution in the form of flat plates. The acetous salt of zink fulminates on hot coals with a blueish flame. By distillation it affords an inflammable liquor, a yellowish oily fluid, which soon becomes of a deep green; and a white sublimate, which when set on fire by a candle, burns with a beautiful blue flame; the residue is in the state of a pyrophorus, not very combustible.

The acid of vinegar does not dissolve mercury in its metallic state; but this combination may be made by dividing the mercury into very small particles, as was done

done by Keyser. Mercury, in the state of calx, readily unites with vinegar. The acid may be boiled either on precipitate per se, on turbith mineral, or mercury precipitated from its nitrous solution by the vegetable alkali. The fluid becomes white, but recovers its transparency when boiling hot; it is then to be filtered, and silver-coloured crystals fall down, in scales resembling sedative salt. This has been called mercurial foliated earth, or mercurial acetous salt. It may be immediately prepared by pouring a nitrous solution of mercury into an acetous solution of vegetable alkali; the nitrous acid unites with the fixed alkali of this last salt, and forms nitre, which remains dissolved; while the calx of mercury, combining with the acid of the vinegar, is precipitated in the form of brilliant scales. The mixture being then filtered, the mercurial acetous salt will remain on the filter. This salt is decomposed by the action of fire, and its residue affords a kind of pyrophorus. It is quickly altered by combustible vapours.

Tin is not much altered by vinegar. This acid dissolves only a small quantity of that metal, which by solution afforded Mr. Monnet a yellowish substance resembling gum, and of a fetid smell.

The acid of vinegar acts more strongly on lead than on most other metals, and dissolves it with the utmost facility. When thin plates of this metal are exposed to  
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the vapour of heated vinegar, they become covered with a white powder called ceruse, which is a calx of lead. Ceruse ground with one third part of chalk, forms the white lead used as a paint. In order to saturate vinegar with lead, the acid is poured on ceruse in a matrafs; the mixture is set to digest on a sand bath, and after several hours is evaporated to a pellicle; by cooling it affords white crystals, forming either irregular needles, if the fluid has been too much concentrated; or flat parallelipipedons, terminated by two slant sections, when the evaporation has been well made. This is called salt or sugar of Saturn, on account of its sweet taste, which is at the same time very styptic. A salt of the same nature is made, by boiling equal parts of litharge and of vinegar, and evaporating it to the consistence of syrup. This is the extract of Saturn of Mr. Goulard, which long before his time was known by the name of vinegar of Saturn. Salt of Saturn, or the acetous salt of lead, is decomposed by heat; it affords an acid, ruddy, and very fetid liquor, different from radical vinegar. The residue is a very good pyrophorus. This salt is decomposed by distilled water, by lime, by alkalis, and by the mineral acids. The extract of Saturn, diluted with water, and mixed with a small quantity of brandy, forms the vegeto-mineral water.

Vinegar

Vinegar quickly dissolves iron; the effervescence which takes place in this solution arises from the disengagement of inflammable gas afforded by the water, which seems to be decomposed. The liquor has a red or brown colour; and by evaporation affords only a gelatinous magma, together with some long brown crystals. The Martial acetous salt has a styptic and sweetish taste; is decomposed by fire, which drives off its acid; attracts the moisture of the air, and is decomposed in distilled water. When heated till it no longer emits a smell of vinegar, it leaves a yellowish calx attracted by the load-stone. The acetous solution of iron affords a very black ink with nut-galls, and may be successfully used in dying. The phlogisticated alkali precipitates a very bright Prussian blue. Martial æthiops, the precipitates of iron, the saffrons of Mars, the sparry iron ore, afford solutions with vinegar of a very fine red colour.

Distilled vinegar dissolves copper with very great facility, and by the assistance of heat it gradually assumes a green colour. But the acid acts more readily on this metal when already calcined by vinegar, and converted into the substance called verdigris. Verdigris is prepared in the neighbourhood of Montpellier, by plates of copper in earthen vessels, covered in layers with the husks of grapes, which have been previously sprinkled



and fermented with weak vinegar. The surface of these plates soon become covered with a green rust, which is increased by piling them together, and sprinkling them with weak vinegar. The copper is then scraped, and the verdigris is packed in sacks of leather for sale. M. Monnet, apothecary at Montpellier, has very well described this process, in two Memoirs printed among those of the Academy of Sciences, for the years 1750, and 1753. Verdigris readily dissolves in vinegar, and the solution, which is of a beautiful green colour, affords by evaporation and cooling, green crystals, in truncated quadrangular pyramids, called crystals of Venus. The crystals prepared for commerce, which are called distilled verdigris, because distilled vinegar is used in preparing them, have the figure of a pyramid; its crystals assume this form, because they are deposited on a stick cleft into four branches, which are kept asunder by a piece of cork.

The acetous salt of copper has a strong taste, and is a violent poison. It is decomposed by the action of fire, effloresces in the air, and becomes covered with a powder, whose green colour is much paler than that of the salt itself. It is completely dissolved in water without decomposition. Lime-water and alkalis precipitate the calx of copper.

When

When this salt is pulverized and distilled in an earthen or glass retort, a fluid is obtained at first pale and scarcely acid; but affords afterwards one so strong, as to resemble the mineral acids. The receiver must be changed during the operation, in order that the phlegm and the acid may be had separate; the latter is called radical vinegar. It has a green colour, arising from a certain quantity of the calx of copper which comes over. When the distillation ceases, and the bottom of the retort is red hot, the residue is a brown copper coloured powder, which often communicates a metallic tinge to the sides of the vessel. This residue is strongly pyrophoric, as the Duc D'Ayen and Proust have observed. Radical vinegar is rectified by distillation with a gentle heat; it is then perfectly colourless, provided the heat has not been urged too strongly, so as to dry the remaining calx of copper. The reduction of the copper reserved in this experiment explains the nature of radical vinegar. This acid appears to have the same relation to common vinegar, as the aerated or oxygenated muriatic acid has to the pure muriatic acid. In this operation the acetous acid unites with the oxygenous principle of the calx of copper, which at the same time resumes the metallic state. The very different effects produced by radical vinegar, compared with those of the common acetous

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acid,

acid, appear therefore to arise from its excess of the oxygenous principle.

Radical vinegar, thus rectified, has so strong and penetrating a smell, that it is impossible to support it for any length of time; its causticity is such, that it corrodes and burns the skin, and it is extremely volatile and inflammable. When heated with contact of air, the rapidity with which it burns is the greater, the more highly it is rectified. This experiment has induced chemists to believe, that vinegar is an acid combined with an ardent spirit; it may, perhaps, be considered as a kind of natural ether. This notion is rendered probable, by the penetrating and agreeable smell emitted by the first portions of this acid in distillation. Radical vinegar evaporates entirely, when exposed to the air; it unites to water, with much heat; with earths, alkalis, and metals, it forms the same salts as common vinegar; but its action on combustible bodies is in general much more rapid. The Marquis de Courtanvaux has shewn, that it is only the last portion of the acetous fluid obtained by distillation from crystals of verdigris which is inflammable; and that it likewise has the property of being congealed by cold. This last portion when rectified, crystallized in the receiver in large plates and needles, and did not become fluid, at a less heat than about 62  
degrees

degrees of Fahrenheit. In this property likewise it resembles the aerated muriatic acid.

The acid of vinegar, assisted by heat, dissolves the precipitate of gold made from aqua regia by adding a fixed alkali. This solution, precipitated by volatile alkali, affords fulminating gold, as Bergman has shewn. Vinegar does not act on platina or silver, while they are in the metallic state, but it dissolves their calces.

This acid combines with many of the immediate principles of vegetables. It dissolves extracts, mucilages, and essential salts; unites with the spiritus rector, and is considered as the proper solvent of gum resins. It has even after a certain length of time in the way of distillation, a considerable action on fat oils, which it converts into a saponaceous state. But the combination of vinegar with vegetable substances, has been by no means accurately examined.

This acid is used to extract some of the vegetable principles, more especially that of smell; and vinegars of different nature, either simple or compound, are prepared for medical use. The vinegars of squills, colchicum, &c. afford an example of the first; the theriacal vinegar, and the vinegar of the four thieves, are of the second kind. These medicines are prepared by maceration and digestion continued for several days. As the acid is volatile, it is distilled from aromatic plants,



plants, whose odorant principle it takes up; the distilled vinegar of lavender used as a perfume is of this kind; these liquors are in general less agreeable than spirituous distilled waters.

Radical vinegar decomposes spirit of wine, and forms ether with the same facility as the mineral acids, as the Count de Lauraguais has discovered. For this purpose, radical vinegar is poured on an equal quantity of spirits of wine in a retort. A considerable degree of heat is excited. The retort is then placed in a sand bath, with two receivers fitted on, the outer being plunged in cold water or pounded ice. The mixture being quickly brought to ebullition, a dephlegmated spirit of wine passes first, afterwards the ether, and lastly an acid which is stronger as the distillation advances: a brown mass, considerably resembling a resin remains in the retort. Care must be taken to change the receiver as soon as the ethereal smell becomes sharp and penetrating, that the acid may be collected apart from the ether. The ether must be rectified by a gentle heat with alkali. A large proportion is lost in this operation. The formation of the acetous ether is owing to the excess of the oxygenous principle in radical vinegar. Mr. Scheele affirms, that he did not succeed in preparing acetous ether, by adding radical vinegar to spirit of wine, and that he did not obtain it, but by the addition of a mineral acid. Mr. Pœrner

ner had before made the same remark concerning the difficulty of obtaining acetous ether by the process of Mr. de Lauraguais. However, many French chemists have executed that process; and I can myself affirm, that I have repeated it with success.

M. de la Planche, the apothecary, prepares acetous ether, by pouring oil of vitriol and spirit of wine on salt of Saturn, introduced into a retort. The theory and practice of this operation, are absolutely the same as those of the nitrous and muriatic ethers, prepared by a like process.

The acetous ether has an agreeable smell like other ethers, but it always partakes of the smell of vinegar, though it is not acid. It is very volatile and inflammable, burns with a bright flame, and leaves a coaly mark after its combustion.

Vinegar is much used as to season food. It is likewise of excellent use in medicine, as a refreshing and antiseptic fluid. A syrup is made with sugar, which is given with great success in burning or putrid fevers, &c.; this acid, externally applied, is astringent and bracing. All its combinations are likewise applied to medical uses.

The acetous salts of vegetable and mineral alkali, which are known by the names of terra foliata tartari, and mineral acetous salt, are powerful deobstruent and aperient remedies;

medies; they are administered in the dose of from half a drachm to a drachm.

The spirit of Mindererus, or solution of ammoniacal acetous salt, taken in the dose of a few drops in a proper liquid, is aperient, diuretic, cordial, antiseptic, &c. It often succeeds in the leucophlegmatia, or swelling of the external parts of the body.

The Mercurial acetous salt, or Mercurial terra foliata, is an excellent anti-venereal; it is the principal ingredient in Keyser's pills.

The extract of Saturn, vinegar of Saturn, and the vegeto-mineral water are applied externally as desiccatives. These medicines, being strongly repellent, ought to be administered with great caution, especially when applied to parts which are ulcerated or without skin. Boerhaave mentions several young women attacked with consumptions, in consequence of the external use of preparations of lead.

Ceruse enters into the composition of drying unguents and plasters, and verdigris is a component part of several collyria and unguents.

Radical vinegar is used as a very powerful stimulant to be respired by such as fall into fainting fits. For the convenient use of this remedy, a certain quantity is poured on vitriolated tartar grossly powdered, which is kept in a well closed bottle; this medicine

is

is universally known by the name of salt of vinegar.

Acetous ether has not yet been applied to any use; neither is it known whether it has any peculiar virtues, differing from those of the other ethers.

## C H A P. XXIV.

### Concerning the Putrid Fermentation of Vegetables.

**A**LL the vegetable substances, which have passed the spirituous and acid fermentation, are susceptible of a third intestine commotion, by which they are changed; this is called the putrid fermentation. Stahl, and several other chemists, have thought, that this kind of fermentation is merely a consequence of the two preceding, or rather that these three phenomena depend on a single process, or motion, which tends to destroy the texture of solid substances, and to change the properties of fluids. It is true, in fact, that if certain vegetable substances be left to themselves, they pass through the three fermentations successively, and without interruption. For example; all saccharine matters, dissolved in a certain quantity of water,



water, and exposed to a degree of heat of about 60 or 80 degrees, afford, first wine, afterwards vinegar, and at last the acid character is destroyed; they putrify, lose all their volatile principles, and become dry, insipid, and earthy. But it must be observed, that a great number of vegetable substances do not pass through these three kinds of fermentation, at least as far as sense can distinguish. Insidid mucilages, and solutions of gum in water, become sour, without exhibiting any appearance of spirit; and the glutinous matter appears to pass immediately to putrefaction, without previously becoming acid. It therefore appears, that though these three fermentations succeed each other in many of the vegetable principles, there are nevertheless many others which are capable of the two last, without the foregoing, or even of putrefying, without exhibiting previous signs of acidity. These last participate of the nature of animal substances, and afford volatile alkali by the action of heat, and mephitic by the nitrous acid. It appears to be from this character, that the vegeto-animal substances putrefy so readily.

The intestine motion which changes the nature of vegetable matters, and reduces them to their elements, requires the following conditions. Humidity, or the presence of water, is one of the most necessary; dry  
and

and solid vegetables, such as wood, are not at all changed, while they remain in that state; but if they be moistened, and their fibres separated, the intestine motion soon commences: water, therefore, appears to be one of the causes of putrefaction; and we shall see, in the animal kingdom, that the decomposition of this liquid appears to produce fermentation. Heat is not less necessary. Cold, or the temperature of ice, not only opposes this spontaneous destruction, but retards its progress, and in some measure restores the former state of substances which have begun to change. The degree of heat, necessary to putrefaction, is much less than that which maintains the spirituous and acid fermentation, since it requires no more than about 45 degrees of temperature; but a stronger degree of heat is more favourable to this process, provided it be not so strong as to volatilize all the humidity, and intirely to dry the substance which putrefies. Access of air is a circumstance which singularly promotes putrefaction, since vegetable substances are very well preserved in a vacuum. This preservation, however, has its limits; and the contact of air does not appear to be indispensable for carrying on putrefaction, like the two conditions before-mentioned.

The putrefaction of vegetables has its peculiar phenomena. Vegetable fluids, which putrefy, become turbid, lose their colour, and  
deposit

deposit different sediments; bubbles rise to the surface, and mouldiness appears at the beginning. Vegetable matters, simply moistened, and soft, exhibit the same phenomena; the commotion is never so great as in the spirituous and acetous fermentations. The bulk of the matter which putrefies does not appear to increase, neither does its temperature rise; but the most important phenomenon is the change of smell, and the volatilization of an acrid penetrating urinous principle, similar to the volatile alkali, and which, on examination, is found to be that substance. Hence the putrefactive fermentation has been distinguished by the name of the alkaline fermentation, and the volatile alkali has been considered as its product. The penetrating smell flies off by degrees, and is succeeded by a nauseous, faint smell, not easily described. The decomposition is then at its height; the putrefying vegetable matter is then very soft, or fluid, like a syrup; it experiences a great number of successive modifications in the odorant principle which exhales. Lastly, it dries, its disagreeable smell is dissipated by degrees, and nothing remains but a blackish, and as it were, coaly residue, known by the name of earth, *humus vegetabilis*, in which nothing is found but certain saline and earthy substances. Such is the order of the phenomena observed in the spontaneous decomposition

position of vegetables which putrefy: but this decomposition, carried to that point in which bodies are reduced to their saline or earthy skeleton, requires a very long time; and it may even be added, that it has not yet been properly observed by any person. This reproach which is cast on chemists and philosophers for their inattention to animal matters, is much more deserved with regard to vegetable substances. No philosopher has yet undertaken to observe the complete putrefaction of these last, though many have begun to describe the phenomena which take place in that of animal matters. We may therefore conclude the history of the spontaneous and natural analysis of vegetables, by adding, simply,

1. That the short account we have given shews, that vegetable putrefaction attenuates, volatilizes, and destroys their humours, and reduces them to the earthy state.
2. That nothing is yet certainly known concerning the phenomena and limits of this kind of putrefaction, which requires to be properly distinguished from that of animal matters.
3. Lastly, as this fermentation is much more evident, and has been better observed in the fluids and solids of animal substances, the larger detail we shall enter into, respecting these last, will complete our historical sketch of the known facts relating to putrefaction.



## P A R T IV.

The ANIMAL KINGDOM.

## C H A P. I.

The General Characters of Animals.\*

**A**NIMALS are in general distinguished from vegetables, by locomobility, and more perfect organization. Yet, there are intire classes of these which are fixed to a place; such as the lithophytes, and zoo-phytes, which are produced and die on the same spot. And, on the other hand, certain vegetables have as much motion in their leaves and flowers, as certain animals; for example, shell-worms. The organization

\* We do not here propose to exhibit more than a sketch of the methods of naturalists, to facilitate the progress of beginners in the study of natural history, as treated by the best writers: but our plan does not permit us to enter fully into general considerations on the nature of animals, which have been treated in so elegant and philosophical a manner by the Count De Buffon and Mr. Bonnet. F.

even

even appears less perfect in polypi than in most plants. Hence it is very difficult to draw a true line of discrimination between these two kingdoms; and modern naturalists have therefore been under the necessity of confounding them in one single arrangement, called the organic kingdom.

Nevertheless, when we consider perfect animals, we find great differences between them and vegetables. Numerous and distinct organs, a more complicated structure, and a greater variety of functions, are the characters in which these differences consist; but it does not appear the less difficult to give a good definition of these substances.

By attending to the most general characters, we may define animals to be bodies endued with sensation and motion, necessary to preserve their life. They are all capable of re-producing their like: some, by the union of the two sexes, produce small living creatures; others lay eggs, which require nothing more than a due temperature, in order to produce young. There are some which multiply without conjunction of sexes; and others which are re-produced when cut in pieces, like the roots of plants. The true character, or specific distinction of animals, is not easily assigned. The mixture of races produces numberless varieties; and transportation into different climates occasions numerous changes in the form, magnitude,

nitide, colours, &c. of animals. We can only, therefore, consider those as distinct species, which have constantly the same form, and are perpetuated by the re-production of individuals; and the alterations produced by the intermixture of species, climate, domestication, &c. constitute the varieties.

The number of animals which cover the surface of our globe being very considerable, it would be impossible to distinguish them from each other, if nature had not presented remarkable differences in their external figure, on which distinctions are easily established. Naturalists have at all times been sensible of the utility of these differences, which they have advantageously applied in classing animals into methodical divisions. Although it is certain, that these classifications do not exist in nature, but that the whole chain of created beings is uninterrupted, yet it is certain, that these methods assist the memory, and are of great use in the study of natural history. We may therefore consider these methods, as instruments appropriated to our limited powers, by the help of which we may successfully attend to the riches of nature. Aristotle established only general and simple divisions; but his masterly considerations, respecting the interior and exterior organs of animals, have formed a base, on which the divisions of the first naturalists, such as Gesner, Aldrovandus, Jonston,

Jonston, Charleton, Ray, &c. are in great part founded. These early naturalists have been succeeded by a great number of others, who have rendered the methods more perfect, and have added to the knowledge we possess; but among these last, those whose works more particularly require to be known, and from whom we shall borrow, are Messrs. Klein, Artedi, Linnæus, Brisson, Daubenton, Geoffroy.

After man, whose organization and intelligence place him at the head of animated bodies in a separate class, all other animals may be divided into eight classes; namely, quadrupeds, cetacea, birds, viviparous quadrupeds, serpents, fishes, insects and worms, and polypi. These classes might be more multiplied, but the difficulties would increase in the same proportion, and defeat the purpose of artificial classification, whose sole merit consists in simplicity and perspicuity. Mr. Daubenton, who has paid great attention to the classification of animals, has arranged them in the same manner, and has considered the structure of the principal constituent parts of each, to shew that the classes are gradually degraded, from quadrupeds, which nearest resemble man, to worms, which are the most remote. See Table I.



## C H A P. II.

## Concerning Quadrupeds and Cetaceous Animals.

## ZOOLOGY.

QUADRUPEDS are animals having four feet, whose body is most commonly covered with hair. They respire by lungs similar to those of man; and like him they have a heart, consisting of two ventricles: they are viviparous. These animals resemble man the nearest in their structure; there are even some, as for example, the ape and a few others, which Linnæus has thought proper to include in the same order as man. This naturalist gives the name of mammalia to this class, in which he comprehends cetaceous fish, because they have teats, and give milk to their young. Though this class of animals appears to resemble man in some respects, yet they differ greatly from him in several important particulars. Such are the horizontal situation of their bodies, the form of their extremities, the thickness and hardness of their skin, which is hairy, or covered with a hard and as it were corneous substance,

stance, the prolongation of the vertebræ of the back into a tail, the anterior part of the cranium flat and horizontal, the ears large and long, the bones of the nose and upper jaw very long, and placed obliquely. When we compare this structure to that of the human species, whose body is perpendicular, the bone called radius moveable, the fingers perfectly separate, the thumbs opposed to the four other fingers, and the skin smooth and thin, we shall be sensible how much this conformation exalts its sensibility, and renders it superior to the most perfect of other animals. The anatomy of its internal parts, and the history of its functions, add still more force to those important conclusions.

The ancient naturalists, at whose head Aristotle and Pliny may be placed, have distinguished quadrupeds only by the place of their habitation. For which reason, and the want of accurate descriptions, it is often impossible to ascertain the animals they speak of. Later naturalists, perceiving the disadvantages of this method, adopted another, which is very different; they have availed themselves of the most obvious differences on the external parts of animals, to establish characters readily known, by the assistance of which they may with certainty be distinguished from each other. We shall in this place explain three artificial methods

of classing quadrupeds; namely, those of Linnæus, Vogel, and Brisson.

### The Method of Linnæus.

Linnæus has divided animals with teats, or the mammalia, in seven orders. The first, comprehending those which he calls primates, has for its characters incisive teeth in both jaws; constantly four in number in the upper jaw; two teats on the breasts, and the arms separated by claviculæ: this order contains four genera; man, *homo*; the ape, *simia*; the lemur, or *prosimia*; and the bat, *vespertillio*. It cannot but be admitted that this method is very remote from nature, since it arranges in the same order, creatures so dissimilar as man and the bat.

Animals of the second order are distinguished by the name of bruta: their characters are the want of incisive teeth, their feet armed with strong hoofs, and their pace slow. This order includes six genera, which are the elephant, *elephas*; the sea-cow, *trichecus*; the sloth, *bradypus*; the ant-eater, *myrmecophaga*; the——— *manis*; the tatow, *dasyfus*. The two first genera are very remote from the four others.

In the third order, the Swedish naturalist distinguishes savage beasts by the name of fera. In this he comprehends all animals with teats, whose incisive teeth are conical,  
and

and usually six in number in each jaw, whose canine teeth are very long grinders, not flatted, feet armed with sharp nails, and which tear their prey, and live by destroying other creatures. There are ten genera of this order; the seal, *phoca*; the dog, *canis*; the cat, *felis*; the ferret, *viverra*; the weazel, *mustela*; the bear, *ursus*; the opossum, *didelphis*; the mole, *talpa*; the shrew-mouse, *forex*; and the hedge-hog, *erinaceus*.

The fourth order, intituled glires, or rats, is distinguished by the following characters: the animals which compose it have two incisive teeth in each jaw, and no canine teeth; their feet are armed with claws proper for leaping; they live on barks, roots, &c. This order comprehends six genera; namely, the porcupine, *histris*; the hare, *lepus*; the castor, *castor*; the rat, *mus*; the squirrel, *sciurus*; and the American bat, to which Linnæus has given the name of noctilio.

In the fifth order, he includes, under the name of pecora, such quadrupeds as have incisive teeth in the lower jaw, and none in the upper; whose feet are cloven, and which ruminant. The camel, *camelus*; the musk animal, *moschus*; the stag, *cervus*; the goat, *capra*; the sheep, *ovis*; the ox, *bos*; are the six genera which compose this order.

The sixth order includes, under the denomination of belluæ, such quadrupeds as have the incisive teeth obtuse, and their feet



hoofed. The four genera of this order, namely, the horse, *equus*; the hippopotamus, *hippopotamus*; the hog, *sus*; and the rhinoceros, *rhinoceros*, are very well distinguished from each other by the number of their teeth, and the form of their feet. Lastly, in the seventh order, which comprehends the cetaceous animals, is distinguished from all others by the form of the feet, which resemble fins: but as we think proper, with many modern naturalists, to make a peculiar class of cetaceous animals, we shall speak of them after quadrupeds.

The method of Linnæus appears to be defective in many respects; not only in its arranging together animals so dissimilar as man and the bat, &c. and separating animals so similar as the rat and the mouse, &c. but likewise because the divisions are not sufficiently numerous, and do not readily enable us to distinguish each quadruped; which last requisite is indispensably necessary, and is in fact the only advantage a method is required to possess.

#### The Method of Klein.

Klein divides quadrupeds into two principal orders: in the first, he arranges those whose feet are ungulated, *pedes ungulati sive cheliferi*; in the second, those whose feet are digitated, *pedes digitati*.

The

The first order is divided into five families, whose characters are founded on the division of their ungulated feet in several pieces. The first family, called *monochela*, comprehends the genus of the horse: the second, whose individuals are distinguished by the name *dichela*, includes all those whose feet are cloven into two parts, *bifulci*. Some have horns, as the bull, the ram, the goat, the stag, &c. others are not horned, as the hog, the boar, the babyroussa. The *trichela*, or animals, whose ungulated feet are divided into three parts, compose the third family, of which the rhinoceros is the only variety. The fourth family, whose character consists in the feet being divided into four pieces, *tetrachela*, contains only the hippopotamus. The fifth, which is distinguished by the feet being divided into five parts, *pentachela*, includes only the elephant.

The second order of quadrupeds, whose feet are digitated, is likewise divided into five families; the first comprehending animals with two digits, *didactyla*, consists of the camel and the filenus, or sloth of Ceylon. The second family, or animals of three digits on their feet, *tridactyla*, includes the sloth and the ant-eater. The third, or *tetradactyla*, or animals of four digits, contains tatous, or armadillos, and Guinea pigs, which seem to be a species of rabbits. The fourth

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family,

family, characterized by five digits on the feet, *pentadactyla*, is the most numerous of all; it contains the rabbit, the squirrel, the dormouse, the rat and the mouse, the opossum, the mole, the bat, the weazel, the porcupine, the dog, the wolf, the fox, the coati, the cat, the tyger, the lion, the bear, the ape: the number of species comprehended under these genera is very considerable. It must be observed, that in all these characters; taken from the form of the feet, Klein considers only the fore feet in his distinction of families. Lastly, the fifth family consists of animals whose feet are irregular, *anomalopedia*; such are the otter, the castor, the sea-cow, and the seal.

The same objection may be made to the system of Klein, as to that of Linnæus. Though his first divisions are sufficiently distinctive of the families, the genera are not so easily ascertained according to his method, more especially those of the fourth family.

#### The Method of M. Brisson.

M. Brisson has avoided most of these inconveniences, by combining together all the characters of the naturalists who have preceded him. He has availed himself of the number of teeth, or their absence, the form of the extremities, that of the tail, the nature

ture of the appendices, such as the horns, the scales, the prickly spines or quills. His combined method is doubtless the most complete, and best adapted to distinguish any quadruped, and refer it to its proper genus. We here present his divisions in the form of a table; it exhibits the characters of these animals to their respective genera, and has the advantage of being very simple, and easily understood. See Table II.

### Concerning Cetaceous Animals.

Cetaceous animals are of a large size, inhabit the ocean, and by the structure of their lungs and blood-vessels, are capable of living in water, as we shall more fully explain in the history of respiration. They resemble quadrupeds in the structure of their breasts, and in general of all their internal organs, as well as in their bringing forth living young. But they differ from them in the form of their extremities, which terminate in fins, and in two large apertures, at the upper part of their heads, through which they cast up the water to various heights. Naturalists call these passages *spiracula*. The number of genera of these animals is much less considerable than that of quadrupeds. M. Brisson has distinguished them, 1. Into such as have no teeth, as the whale, *balæna*.



*balæna*. 2. Into such as have teeth only in the upper jaw, as the narwal, or unicorn fish, *monodon*, *vel monoceros*. 3. Such as have teeth only in the lower jaw, as the *phylæter*. 4, and lastly, Such as have teeth in both jaws, as the dolphin, *delphinus*.

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### C H A P. III.

Concerning Birds.

#### ORNITHOLOGY.

**B**IRDS are biped animals, which move through the air by means of wings, are covered with feathers, and have a beak of a horny substance. A great number of interesting facts are observable with regard to these animals, relative to the various form of their beak, the structure of their feathers, the motions they perform, and their manners or habits. The most important of these will be exhibited in the abridgment of physiology, which we shall give in the following pages; but at present we shall only attend to the external characters which naturalists have taken to distinguish birds, and class them methodically. The earlier writers on this part of natural history have established

blished no other differences between birds than such as relate to the places they inhabit. Hence they have distinguished them into birds inhabiting woods, plains, seas, rivers, lakes, &c. Others have distinguished them from their food, into birds of prey, granivorous birds, &c. &c.

But the methodical writers have distinguished birds in another way. Linnæus has divided them after the form of their beak into six orders, like the quadrupeds with which he has compared them. But these divisions do not appear sufficiently extensive, especially when we consider that the number of species in birds is much more considerable than in quadrupeds, since M. de Buffon reckons the quadrupeds at two hundred, and the birds at fifteen hundred, or two thousand. We shall therefore only mention in this place the methods of Klein and of Brisson.

Klein divides birds into eight families, after the form of their feet; the first under the name of *didactyles*, comprehends such as have two digits on their feet; the ostrich is the only species in this division. The second contains the *tridactyles*, such as the casuary, the bustard, the lapwing, and the plover. The third contains the *tetradactyles*, which have two digits behind and two before; such as the parokeet, the wood-pecker, the cuckcow, and the king-fisher. The fourth

fourth contains the *tetradactyles*, three of whose digits are before, and one behind. This family is the most numerous of any, as it comprehends the birds which prey by day and by night, such as the raven, the magpye, the starling, the thrush, the black-bird, the lark, the red-breast, the swallow, the titmouse, the woodcock, &c.

The fifth family contains the *tetractyles*, whose three anterior digits are united by a membrane, and the posterior at liberty. These birds are called *palmipedes*; the goose, the duck, the sea-maw, and the diver, compose this family. The sixth includes the *tetradactyles*, whose four digits are united by a membrane. These in latin are called *planci*. The pelican, the cormorant, the booby, and the anhinga, are arranged by Klein in this family. The seventh is composed of such as have only three digits, and these united by a membrane; they are called the *tridactyles palmipedes*. The guillemot, the penguin, and the albatros, belong to this family. Lastly, the eighth class includes the *tetradactyles*, whose digits have membranes fringed, or as it were torn; these are also called *dactylobes*. Coots, and some of the species of divers, compose this last family. The method of Klein, though more comprehensive than that of Linnæus, is notwithstanding attended with many difficulties in ascertaining the genera, especially that  
of

of the fourth family; for which reason we think the method of M. Brisson is to be preferred. It must be confessed, however, that this last, in which the author has used all the characters together, as he has done with respect to the quadrupeds, appears very complicated at first sight; but when it is reduced into a table, as we have done, all its divisions may be readily distinguished; and any bird may be easily known by attending to the characters according to their arrangement. See table the third at the end of this volume.

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#### CHAP. IV.

##### Concerning Oviparous Quadrupeds, and Serpents.

LINNÆUS classed together, in his system, under the denomination of amphibia, the oviparous quadrupeds, serpents, and cartilaginous fishes: but M. Daubenton observes, that the word amphibious cannot be applied to any peculiar class of animals; because, if the expression be applied to animals who live as long as they please either in the air or in the water, there are none which possess that advantage; and  
if



if it be applied to terrestrial animals, which are able to remain a certain time in the water, or to aquatic animals, which are capable of living a certain time in the air, all animals would be amphibious. He therefore makes two orders of oviparous quadrupeds and serpents, and arranges the amphibians of Linnæus among the fishes.

The oviparous quadrupeds form the fourth order of animals in the division of M. Daubenton. Their organization is considerably perfect, since like the quadrupeds, cetaceous animals, and birds, which precede them, they have a head, nostrils, and internal ears. But they differ in the following characters: 1. They have but one ventricle in the heart. 2. Their blood is almost cold. 3. They inspire and expire the air at long intervals. 4. They are oviparous, and consequently without breasts; this last character is common to them with the four orders of animals which follow them. Lastly, the existence of four feet without hair, is peculiar to this order.

M. Daubenton remarks, that the several genera of this order of animals differ too much from each other, to admit of any general description applicable to the whole. He therefore applies the general characters in the history of each genus; as for example, at the words tortoise, lizard, toad, frog, &c. in the second volume of the Natural History

History of Animals, which composes part of the *Encyclopédie Méthodique*.

As the methodical disposition, and the characters of the orders of oviparous quadrupeds, as laid down by this celebrated naturalist, are the most accurate and complete of any which have yet come under my observation, I have united all the divisions of M. Daubenton from the classes to the species; because these last are no more than a hundred in number. See the fourth table.

Serpents form the fifth order of animals in the division of M. Daubenton. The scales with which they are covered, and the absence of feet and fins characterize them very well. They have a head, nostrils, internal ears, a single ventricle in the heart, the blood almost cold, their respiration is made at long intervals, and they lay eggs like the oviparous quadrupeds. Serpents have neither neck nor shoulders, and the scales which cover them are of three kinds. They are either rhomboidal, and cover each other in the manner of tiles, which Linnæus calls *squammæ*; or they are of a long square form, touching without covering each other; Linnæus calls these *scuta*: they are only observable on serpents; when they are very small and of the same form they are called *scutella*; or lastly, they consist of rings encircling the bodies of serpents, as is seen in the *amphisbena*.

Serpents,

Serpents, though without feet, sometimes move with considerable swiftness, by leaning first on their anterior part, raising up the middle, and bringing forward the posterior part of their body; by which means they raise themselves on their tail, and spring to some distance, in order to seize their prey. They cast their skin once or twice in the year.

Some serpents are venomous; out of 131 species noted by Linnæus, 23 are dangerous, according to that naturalist. All these animals, whose bite is venomous, have on each side of the upper jaw, a tooth much larger than the others, together with a reservoir filled with a peculiar liquor, which passes into the wound through a perforation in the tooth.

It is established, by the most authentic testimony, that some serpents are of a prodigious size. Mr. Adamson, from very exact data, fixes the magnitude of the largest serpents at 40 or 50 feet in length, and a foot, or a foot and a half in thickness. M. Laurenti has paid greater attention than any other naturalist to the classification of serpents. He distributes them into seventeen genera; but the difficulty of observing the distinctive characters, has prevented M. Daubenton from adopting his method; this last naturalist has therefore followed Linnæus in the fifth table. I have inserted the divisions and characters of serpents from the genera to

127 species, noted by M. Daubenton. See table the fifth.

## C H A P. V.

### Of Fishes.

#### ICHTHYOLOGY.

**FISHES** are animals very different from the foregoing: their interior organs are of a peculiar structure, as we shall observe in our abridgment of physiology. They are distinguished from other animals by their having no feet, but fins, by which they move in the water, and by their respiring water instead of air. It is much more difficult to make observations on fishes than on other animals, and for that reason their natural history is in a much less advanced state.

In order to understand the methodical division which we propose after Artedi, Linnaeus, and Gouan, it will be necessary to take a cursory view of the anatomy of their external parts. The bodies of fishes may be divided into three parts; namely, the head, the trunk, and the fins.

The head of these animals is differently formed. It is either flattened horizontally, or laterally, or else round; naked, or co-



vered with scales ; smooth, or covered with asperities, tubercles, & c. Their mouths are observed to have lips either of flesh or of bone, with appendages; or soft and very moveable barbulae ; the teeth fixed either to the jaws, the palate, the tongue, or the throat ; the eyes two in number, motionless, and without eyelids ; the perforations of the nostrils double on each side the opening of the gills or branchiae ; the opercula, or round triangular or square bones designed to close the aperture of the branchiae ; the branchial membrane placed beneath the opercula, sustained by several bones in the form of an arch, whose number varies from two to ten. This membrane is folded up beneath the opercula, and must be well examined with respect to its structure and varieties, because the characters of the genera are most commonly taken from the number or form of its radii.

The trunk is of various forms as well as the head ; it is either round, globular, long, flat, or angular. The observer must take notice of the lateral line, which seems to divide each side of the body into two parts ; the thorax placed beneath the gills at the commencement of the trunk, and containing the heart and the branchiae ; the belly, whose ribs form the principal supports of the fins continued from the head to the tail, and which contains the stomach, the intestines,

intestines, the liver, the air bladder, the parts of generation; the opening of the anus, which is common to the intestines, the bladder, and the generative parts; lastly, the tail, which terminates the trunk, and is of various forms and magnitudes.

The fins, *pinna natatoria*, are formed of membranes supported on small radii, some of which are hard, bony, and terminate in a sharp point, which characterizes the fishes called *acanthopterygiani*, so denominated by Artedi; others are flexible, soft, obtuse, and as it were cartilaginous, which characterizes the fishes called *malacopterygiani*. Five sorts of fins are distinguished with respect to their situation; the dorsal, the pectoral, the abdominal, together with those of the anus, and of the tail.

The dorsal fin is impair; it maintains the fish in equilibrium, and varies in situation, number, figure, proportion, &c.

The pectoral fins are situated at the aperture of the gills; they are two in number, and perform the office of arms, and sometimes of wings. They differ as to the place of their insertion, extent, figure, &c.

The abdominal fins are of the greatest importance to be known, because their situation has been assumed by the celebrated Linnaeus, as a distinctive character in the classification of fishes. These fins are placed at the inferior part of the body, under the belly, before

the anus, always lower and nearer to each other than the pectoral fins. They are sometimes wanting; and as Linnæus has compared them to feet, he calls those fishes which are without them *apodes*; but they exist in the greatest number of fishes. Their insertion varies; when they are placed forward or beneath the aperture of the gills, and the pectoral fins, they are called jugular; and the same name is likewise applied to the fishes in which it occupies this place. If they be attached to the thorax behind the opening of the gills, they are then called thoracic; and the fishes which possess this structure are distinguished by the same name in the method of Linnæus. Lastly, when they are placed beneath the belly, nearer the anus than the pectoral fins, they are denoted by the name of abdominal, which term is likewise applied to the fishes distinguished by this structure.

The fin of the anus is impair. It occupies either wholly, or in part, the region situated between the anus and the tail; it differs in form, extent, and number, though it has not been observed double, excepting in the gold fish of China.

The tail fin is placed vertically at the extremity of the body, and terminates the tail. It is the rudder of the fish, or instrument by the various motions of which it changes its direction at pleasure. It likewise

wise exhibits many varieties in its form, adherence, connection, extent, &c.

After these details respecting the external anatomy of fishes, we shall proceed to mention the methodical divisions of naturalists. Before the time of Artedi, no naturalist had attempted to arrange fishes in a methodical manner; though several methods were before used for the classification of other animals. This philosopher proposed a system of Ichthyology, founded on the nature of the bones of the fins, whether hard or soft, pointed or obtuse, and on the form of the gills. He afterwards attempted to multiply the divisions by attending to the other parts; but a premature death terminated his labours. Linnæus attempted to establish an Ichthyologic method, from the various situations of the belly fins; and Mr. Gouan, a celebrated professor at Montpellier, has very skilfully combined the two systems of Artedi and Linnæus. This naturalist first divides fishes into such as have their gills complete; that is to say, consisting of an aperture and a complete branchial membrane, and those which have their gills imperfect; that is to say, wanting either the opercula, or the branchial membrane, or both. The first are afterwards distinguished from each other by the form of their fins. These parts are in fact composed either of hard and sharp bones, or soft, and as it were cartilaginous radii,



radii. These differences constitute three classes of fishes, namely, 1. The acanthopterygiani. 2. The malacopterygiani. 3. The branchiostegi. In each of these classes of fishes, the belly fins are either wanting, or placed at the neck, thorax, or belly. Mr. Gouan has divided each class into four orders; that is to say, apodes, jugular, thoracic, and abdominal.

The distinctive characters of the genera, which immediately follow these divisions, are founded on the form of the head, of the mouth, of the branchial membrane, and more particularly on the number of radii which support this membrane. See Table VI.

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## C H A P. VI.

### Concerning Insects.

#### ENTOMOLOGY.

**I**NSECTS are animals which are known by the form of their body, which is divided as it were into rings, and by two moveable horns which they have on their head, and are distinguished by the name of antennæ. Insects compose one of the most numerous classes of animals, doubtless, on account of their minuteness; for  
it

it has been observed, the smaller these creatures are, the more numerous is their production. The history of these animals is highly agreeable and amusing, and perhaps not the least in point of utility; since discoveries respecting their properties may prove exceeding useful in the arts, and in medicine.

The classes of insects exhibit resemblances with almost every other animal, with respect to their manners, form, habitations, &c. Some walk like quadrupeds; others fly like birds; others again swim, and live in the water like fishes; and lastly, there are others which leap, or crawl along, like certain reptiles. This analogy may even be carried much farther, by a full examination of the structure of their extremities, their mouth, their internal organs, &c.

Insects externally considered, are composed of three parts; namely, the head, the thorax, and the abdomen.

The head differs in its form, size, and position. It is sometimes very large, and sometimes very small, with respect to the bulk of the insect. It is either round, square, or long; smooth, rough, tuberculated, or tufted with hair. We may observe the antennæ placed near the eyes, consisting of different articulated and moveable pieces, resembling a thread terminated either by

a point or a knob. The form of these organs must be carefully distinguished, because this character is almost always used to distinguish the genera. 2. The eyes; which are of two sorts, either in facets, or resembling net-work, smooth and small. These organs are very large in some insects, and in others very small. Their number is various; there are insects which have only one eye, as the monocolus; others have two, five, or even eight, as for example the spider, &c. 3. The mouth; which is formed either of strong and corneous jaws, moveable laterally, or consists of a trunk of various lengths dilated, spiral, &c.; or a simple, cleft, &c. This part is frequently ornamented with small moveable appendices, called antennulæ, to the number of two or four.

The thorax is the stomach of insects. It is placed between the head and the belly, and is either round, triangular, cylindric, thick, slender, &c. It may be considered as composed of six faces, like a cube, which form it sometimes has. The face, or anterior extremity, is hollowed to receive the head. This articulation is sometimes made only by a part as small as a thread, as in flies. The posterior extremity is usually rounded and articulated with the first ring of the abdomen, and is sometimes joined with this part only by a thread. The superior surface is either

ther flat and smooth, rounded, prominent, with appendices, or tubercles, or terminated by a kind of border, turned up, which constitutes the thorax marginatus. The wings are attached at the posterior part of this surface. Most insects are provided with these organs; but as they differ singularly from each other, and the principal divisions of classes adopted by methodical writers are founded on these differences, it will be necessary to attend more particularly to them.

The wings are either two or four in number; among those which have two transparent wings, as the fly, the gnat, &c. these wings always have beneath the place of their insertion a slender thread terminated by a round button, called balancers, *halteres*, which is covered by a concave membranous substance. In a great number of insects these two wings are very strong, and folded up under hard, horny, moveable coverings, called sheaths, or *elytra*. These differ in form; some cover the whole abdomen; others are, as it were, cut transversely, and cover only a part; some are hard, and others soft, and most of them towards the top of the suture, or line, at which they are applied to each other, have a small triangular piece affixed to the thorax, which is called scutellum; but this piece is wanting in some. Lastly, in many insects the *elytra* are fastened together, and  
are



are formed of one motionless piece. The wings are often four in number, and are thin membranes, and transparent, as in the libella, the wasp, &c. or they are covered on each surface with a coloured powder, which, under the microscope, appears to consist of scales, placed over each other like tiles, *imbricatim*.

The inferior part of the thorax is irregular, consisting of several pieces fastened to each other; and some of the legs are fixed to it. The number of legs varies in insects; some have six, and others eight, like spiders: others have ten, as the hornet. Lastly, there are insects which have a much larger number; the wood-lice have sixteen; and some of scolopendra, and centipedes, have as many as seventy, and one hundred and twenty, on each side. Among those which have no more than six, eight, or ten, they are all attached to the thorax, according to Geoffroy; among those which have a larger number, some are inserted in the rings of the belly.

The leg of an insect is always composed of three parts; the thigh, which joins to the body, the leg, and the tarsus. There is often an intermediate piece between the body and the thigh. The tarsus is formed of many pieces, or rings, articulated together, whose number varies from two to five. In some insects, the tarsus is more considerable

able in the fore than in the hind feet; a circumstance which established an analogy between these creatures and many quadrupeds, whose fore-feet have a greater number of digits than the hinder. M. Geoffroy has availed himself of this character, in his division, as we shall hereafter see. The tarsus is terminated by two, four, or six, small claws, or hooks, and is often furnished with brushes, or spongy balls, on its lower part, by means of which the insect is capable of walking on the most polished substances, such as glass, &c. in any position.

On each side of the thorax, one or two oblong, oval apertures are observed, which are called stigmata, through which the insect respire.

The third part of insects is the abdomen. It is most commonly composed of corneous rings, or half rings, which slip over one another; in some the rings are not observed, and the abdomen appears to be formed of a single piece: it is usually larger in males than females. The parts of generation are placed at its extremity; a stigma is observable on the side of each ring, except the two last. Many insects have stings at the posterior part of their abdomen, some of which are sharp and piercing, others in the form of a saw, and some of that of a gimblet. They serve either as instruments of defence, or to penetrate

trate substances in which the insects deposit their eggs.

The most singular phenomenon, in which insects differ intirely from most other animals, consists in the changes of state through which they pass, or the metamorphoses they are subjected to, before they become perfect insects. There are some insects, and almost all the class of aptera, which do not undergo these changes, but the greater number are subject to them; the insect does not come out of the egg with the form of the mother, but in that of a worm, with or without feet, the structure of its head and the rings being exceedingly various. This first state is the caterpillar; under this kind of mask, the insect eats, grows, moves, and changes its skin several times. When it has grown to its full size, it changes its skin for the last time, and no longer appears under the form of a worm, but under a different form, called *nympha cbrysalis, aurelia*.

M. Geoffroy distinguishes four kinds of nymphæ: the first is that which does not resemble an animal; a few rings only are observed at the lower part, and the upper part exhibits indistinct impressions of antennæ, legs and wings. The skin of this kind is hard, cartilaginous, and it has only a slight motion in its rings. The butterfly, phalæna, &c. are of this kind.

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The second kind of chrysalis admits of the parts of the perfect animal being distinguished beneath a thin and very soft skin. It is motionless, like the foregoing. Insects with hard coverings to their wings, those with four naked wings, and those with two wings, afford examples of this kind.

The third species, is that whose parts are perfectly developed, and which move; such are those of the gnats and insects which pass the two first stages of their life in the water.

Lastly, the fourth species comprehends those which resemble the perfect insects in the form of their body, their antennæ, and paws: these nymphæ move, and eat; they differ from perfect insects only in the want of wings, and in their being incapable of procreating. The nymphæ of the libella, of the bug, of grasshoppers, and of crickets, &c. are of this kind.

Insects, like other animals, were only distinguished by the ancient naturalists from the places of their habitation. No one before the time of Linnæus attempted to dispose them methodically, according to distinguishing characters. After Linnæus, to whom we are indebted for the first systematic division of these animals, M. Geoffroy attempted to class them in a more accurate manner; his division of sections in genera is a masterpiece of the kind, for precision, accuracy,  
and



and perspicuity: we shall therefore follow his system. M. Fabricius has since availed himself of the form of the jaws to divide insects.

M. Geoffroy divides insects into six sections, according to the absence, the number, and the structure of the wings: the first section includes the *coleoptera*, or insects whose wings are covered with cases. Their mouth, which is armed with two lateral and corneous mandibles, forms likewise a general character of this section. The May-bug exhibits both these characters.

The second section comprehends the *hemiptera*, whose superior wings are either in a small degree thick and coloured, or rather hard and opaque; but as the character of the wings is not strongly marked in this section, it is replaced by that of the mouth, which is constant. This mouth is a long and slender trunk, turned inwards between the feet: the wood-bug and the cicada are of this section.

The third section is composed of *tetraptera*, with farinaceous wings, the four wings being coloured by a scaly powder. These have a trunk more or less long, and often of a spiral form, as in the butterfly: Linnaeus calls these *lepidoptera*.

In the fourth section are placed the *triptera*, with bare wings. Their four wings are membranous, and their mandibles  
are

are hard: the wasp is of this kind. Linnæus has made two orders of these insects; namely, the *neuroptera*, whose anus has no sting, and whose wings have nervous marks; and the *hymenoptera*, which have the anus armed with a sting, and the wings membranous, without any very apparent nerves.

The fifth section contains the *diptera*, or insects with two wings; their mouth is most commonly in the form of a trunk, and they have ballancers under the insertion of their wings.

Lastly, in the sixth and last section are classed, the *aptera*, or insects without wings, such as the spider, the louse, &c.

Besides these primary divisions, M. Geoffroy has established others, to facilitate the distinction of insects. See Table VII.

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C H A P. VII.

## Of Worms.

**W**ORMS are soft animals, of a very different form from insects, with which they have been confounded by several naturalists, their organization being less perfect than that of those animals. They have no bones, properly speaking; and their members are not constructed like those of insects, neither are they, like them, subject to pass through different states. Their organs, destined for the purpose of generation, are not known; many worms have no head perfectly formed; and lastly, the absence of feet and scales distinguish them from all other creatures. The class of worms is the most numerous, and the least known, of all animals. There are few organic substances, either living or dead, in which certain worms are not found, that subsist and are nourished within them. Most naturalists have placed worms and polypi in the same class; but it would perhaps be better to separate them, since their internal structure and functions perfectly distinguish them from each other. We know that most worms contain a heart,  
and

and vessels, but nothing similar has been discovered in polypi. The worms we now speak of must not be confounded with the *larvæ* of insects or caterpillars, which have likewise been called worms, merely on account of their form. Their head, furnished with mandibles, and their legs, which are more or less numerous, consisting commonly of six, afford characters by which they may be easily distinguished.

Worms have a considerable degree of activity, and in general love moisture. Some have not a head which can be easily distinguished; most of them are hermaphrodites. Such as have a head, have two moveable horns, which they can retract, and are called *tentacula*. All the worms, of which we are now giving an abridged account, have the property of being re-produced, when cut through; a circumstance which shews, that their organization is simple, and resembles that of polypi.

This class of animals may be divided into four sections: the first contains the naked, or bare worms, whose organization is best known, and which in their leading character resemble other animals; in the second, we shall place worms which have a testaceous covering, or shell-worms; their organs are less known than those of the former section; the valuable researches of Mr. Adanson

VOL. IV. R prove,



prove, however, that their structure resembles that of naked worms. The third section will contain worms with a crustaceous covering; their organization is not so well known as that of the foregoing, their external form and the structure of their mouth only having been examined. And lastly, the fourth section will include the polypi. The methodical divisions of these different sections have already afforded employment to many naturalists; Lister, Linnæus, Klein, Ellis, Pallas, D'Argenville, are those of whose assistance we have availed ourselves, in the imperfect division exhibited in our eighth table. See Table VIII.

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### C H A P. VIII.

The Functions of Animals considered, from Man to the Polypus.

**T**HE characters peculiar to living and organized bodies, consist, as we have already observed, in the different functions executed by means of their organs. We have considered those of vegetables; the order we have adopted now leads us to the functions of animals.

That part of the art of medicine, in which  
the

the functions of animals are examined, is called physiology. This useful and valuable science ought not to be confined to the single consideration of the human species, but should be extended to all animals: in this point of view, we shall cursorily pass over the animal kingdom.

The functions of animals are reducible to the following:

- I. Circulation.
- II. Secretion.
- III. Respiration.
- IV. Digestion.
- V. Nutrition.
- VI. Generation.
- VII. Irritability.
- VIII. Sensation.

These different functions are observed in man, quadrupeds, cetaceous animals, birds, fishes, oviparous quadrupeds, serpents, and insects. Worms and polypi do not possess them all, neither do serpents nor insects possess them in the same degree.

I. The circulation is one of the most important functions. It is indispensably necessary to maintain life. The organs by which it is performed, are the heart, the arteries, and the veins.

The heart is a conical muscle, towards the apex of which are two cavities, called ventricles; and at its base, two other vessels, called auricles. A large artery, named the

aorta, issues from the left ventricle, and distributes the blood to the various parts of the body; another artery, of equal magnitude, issues from the right ventricle, which is called the pulmonary artery, because it is spread into ramifications in the lungs. The right auricle receives the blood which returns from every part of the body, by the two *venæ-cavæ*; whence the fluid passes into the right ventricle: from this last it is transmitted to the lungs, by the pulmonary artery, and is returned, by the pulmonary veins, into the left auricle, and thence to the left ventricle, from which it is propelled to all the parts of the body through the aorta. This motion, as it takes place in man, constitutes two kinds of circulation; that of the whole body, and the pulmonary circulation. The latter was known before the former. Harvey, an English physician, discovered the general circulation.

This function is performed in quadrupeds, cetaceous animals, and birds, absolutely in the same manner as in the human species. In fishes, the heart has but one ventricle, and the lungs, or gills, do not receive blood, by means of a peculiar cavity of the heart. Reptiles resemble fishes in this respect. The heart of insects and worms consists of a series of nodules, which contract one after the other; their vessels are very small, and their blood cold and colourless. Polypi have neither  
heart

heart nor vessels; and are inferior to vegetables, with respect to this function.

II. Secretion is a function, by which different organs separate, from the blood, juices destined to particular uses, as the bile in the liver, &c. This function is one of the most general in animals, and is found in all the classes; but it is not possible to attend to it in each, without entering into too long a detail. It will therefore be sufficient to observe, that in all animals, which have a true circulation, the secretions follow the same laws as in man; and that it even appears to take place in most animals which have not a heart. Besides the analogy that necessarily subsists between man and animals which have the same organs, with respect to the functions we are treating of, certain classes of animals exhibit peculiar secretions, which are not performed in the human species; such are the musk and civet in quadrupeds, spermaceti among cetaceous animals, the oily fluid, with which birds smear their wings, the virulent fluid of the viper, the adhesive fluid of the scales of fishes, the acrid and acid juices of the buprestis, staphylini, ants, and wasps, among insects; the viscous mucilage of snails, the colouring juices of the purple fish or murex, and a great many others, which the natural history of each animal displays.

III. Respiration, considered in all animals, is a function intended to bring the blood into contact with the fluid they inhabit: men and



quadrupeds, for this purpose, have an organ called the lungs. This viscus consists of a collection of hollow vesicles, which are formed by the expansion of a membranous and cartilaginous tube, called the arteria trachea, and of blood-vessels, which form a great number of areolæ at the surface of the bronchial vessels: these vesicles and vessels are sustained by a cellular, loose, and spongy substance, which forms the parenchyma of the lungs. The air distends the vessels by inspiration; the base of the vital air of the atmosphere appears to combine with a principle disengaged from the blood, and forms the cretaceous acid, which is expired, together with the mephitic. The matter of heat, separated from the vital air, unites with the blood, and restores those properties which it had lost in passing through the body.

This function is performed in the same manner in cetaceous animals; excepting, however, that as there is an immediate communication between the auricles, these animals are capable of remaining a considerable time without respiring.

Though the respiration in birds be analogous to that of the animals last treated of, yet it appears to be much more extensive. Anatomists have discovered, in the abdomen of birds, spongy vesicular organs, which communicate with their lungs; and these last extend even into the bones of the wings, which

which are hollow, and without marrow, by a channel placed at the upper parts of the breasts, and which opens in the superior part of the os humeri. This happy discovery of Mr. Camper teaches us, that the air passes from the lungs of birds into the bones of their wings; and that this fluid, rarefied by the heat of their bodies, renders them very light, and singularly assists their flight.\*

Fishes have gills, or branchiæ, instead of lungs; these organs are formed of membranous fringes, disposed on a bony arch, and charged with a very great quantity of blood-vessels. The water enters by the opening of the mouth of fishes; passes through the fringes, which are by that means separated from each other; presses and agitates the blood, and passes out through apertures situated at the two lateral and posterior parts of the head, on which two moveable bony valves, called opercula, are placed, and sustained by the branchial membrane. Duverney supposed that the brachiæ separate the air contained in water. M. Vicq d'Azir, who has paid great attention to the anatomy of fishes, thinks that the water performs the office of air in the branchiæ of these ani-

\* This is doubtful. See Mr. John Hunter's account of certain receptacles of air in birds, which communicate with the lungs. *Philos. Transactions*, vol. 74, for the year 1774. T.

mals. It is certain, that as fishes do not respire air, and convert it into cretaceous acid, their blood does not possess the degree of heat, which the air gives to such animals as respire it.

Insects have no lungs; they have two tubes, or tracheæ, placed along the back, from which, on each side, other smaller tubes issue forth, and terminate at the lateral part of each wing, by a small cleft, called stigma. These stigmata appear rather to be designed to emit some elastic fluid, since insects do not quickly die in a vacuum; though they have convulsions, and expire in a few instants, if the stigmata be covered with oil or varnish. Worms have an organization still less perfect. No kind of respiration has been observed in polypi, which, with respect to this function, are less perfect than vegetables, in which we have observed the tracheæ.

IV. Digestion consists in the separation of the nutritive matter contained in food, and its absorption, by peculiar vessels, called chyliiferous. It is performed in a channel, which is continued from the mouth to the anus, and which, in man, is enlarged towards the upper part of the abdomen. This enlargement is called the stomach. The alimentary canal afterwards becomes narrower, is turned in different directions, and is distinguished by the name of  
of

of the intestines. This long tube, which is formed of muscles and membranes, retains the aliments, so as to extract all the nutritive matter they contain. There are likewise other glandulous organs, near the stomach, whose office is to prepare the fluids requisite to stimulate the stomach and intestines, and to extract the nutritive part of the food: these organs are the liver, the spleen, and the pancreas. The bile and pancreatic juice flow into the first intestine, called the duodenum, and mix with the food. Before this mixture is performed, the aliments are dissolved in the stomach, by the gastric juice.

The whole course of the intestines is covered with vascular apertures, destined to extract the chyle. These vessels convey it into the receptaculum lumbare, in the thoracic duct, and the chyle is poured into the left subclavial vein, in which it mixes with the blood. Such, in a few words, are the mechanism and phenomena of digestion in man.

Quadrupeds differ greatly in the form of their teeth, stomach, and intestines: some of these animals, as the ant-eater, and the scaly lizard, which live on soft food, have no teeth; others, such as the sloth and the armadillo, have only grinders; others, as the elephant, and sea-cow, have molar and canine teeth; lastly, the greater number have the three kinds of teeth, molar, canine, and incisive; but their  
number,



number, position, and strength, are subject to great variations. The most striking circumstance in this various structure of the teeth, is, that, according to the remark made by Aristotle, Galen, &c. there is a constant relation between the number and position of these bones, and the form of the stomach. In fact, all quadrupeds, which have incisive teeth in both jaws, as the horse, the ape, the squirrel, the dog, the cat, have no more than one membranous ventricle, as in man; the anatomists call these animals *monogastrica*: and in these the digestion is performed absolutely in the same manner as in the human species. Quadrupeds, which have incisive teeth only in the inferior jaw, are *polygastrica*, and ruminating; such are the camel, the goat, the ram, the ox, the stag, &c. These quadrupeds, which are usually bisulc, and armed with horns, have four stomachs; the first, called in oxen the paunch, is the largest, and is divided into four other cavities; it receives the aliments at the same time with the second, which opens into the paunch by a large orifice. The herbaceous aliments, contained in these organs, dilate, and the air becomes rarefied; the nerves of these viscera are stimulated, and an anti-peristaltic motion is excited, which returns them, through the oesophagus, into the mouth; where they are again masticated by the molar teeth, and re-

duced

duced into a kind of soft paste. In this state, together with the drink, they are conducted, by a new deglutition, into the third stomach, called the omasus, by means of a duct passing from the oesophagus to this last ventricle. Lastly, they pass from the omasus into the fourth stomach, where they are truly digested. The intestines of ruminating animals, are likewise much more extended than those of monogastric quadrupeds. Cetaceous animals perfectly resemble these last, in the mechanism of the now treated of function. Birds differ from each other in the structure of their stomach; in some it is membranous, and in others fleshy, or muscular. The first sort, which may be called *hymenogastrica*, are carnivorous; all birds of prey are of this species. Their stomach contains a very active juice, capable of softening bones, according to the experiments of Reaumur: their bile is likewise very acrid. The second, which may be called *miogastrica*, subsist only on grain; their stomach is formed of a quadrigastric muscle, armed with a hard and thick membrane, proper for trituration: these birds have likewise a double cæcum.

Fishes have a membranous long stomach, with many appendices; their intestines are in general short. Reptiles exhibit the same structure; their stomachs are capable of an astonishing degree of distension. Serpents are often seen to swallow intire animals, much larger than themselves.

Insects

Insects have a stomach, and intestines, which are well organized. Swammerdam and Perrault affirm, that the mole cricket has four stomachs. Their stomachs are divided into four cavities, as may be easily seen by dissecting this insect, which is very common, and much feared by gardeners. Worms have a very irregular stomach, and likewise small intestines. The polypus seems to be merely a stomach, for it digests very quickly: the same aperture serves this creature both as mouth and anus.

V. Nutrition is a consequence of digestion and circulation. As the solids always lose, or become diminished, by the motions they perform, and require to be repaired, this is performed by nutrition. In the early part of life, they increase in bulk, and the animal grows. The cellular membrane is usually considered as the organ of this function, and the lymph as the fluid proper to restore the solids. It appears, nevertheless, that each organ is nourished by a peculiar and proper matter, which it separates, either from the blood, the lymph, or some other fluid which passes through it. For example; the muscles are maintained by the fibrous matter, which they separate from the blood; the bones extract calcareous phosphoric salt, and lymphatic matter; the pure lymph dries in laminae on the cellular texture; the con-

creffible

creffible oil being at the same time deposited. Each organ, therefore, is nourished in a peculiar manner, and in each, nutrition is a true secretion. Quadrupeds and cetaceous animals perfectly resemble man, with regard to this function. The same remark applies also to birds: but it is performed much less quickly with fishes; for which reason these animals live a very long time: the age of some of them is not known; but in general, the slower the nutrition and the growth, the longer the life.

Insects exhibit nothing remarkable with regard to this function. It must only be observed, that they grow only in the form of larvæ, and not in that of the chrysalis, or of the perfect insect. Swammerdam and Malpighi have proved, that the larva contains a perfect insect, ready formed beneath a number of skins. The caterpillar likewise contains the butterfly, whose wings and feet are doubled up.

In worms and polypi, nutrition is performed in the cellular membrane, and is likewise performed in vegetables, by means of the reticular and vesicular membranes.

VI. Generation, considered in all animals, is performed in many different manners; most of them have different sexes, and require conjunction. Such are the human species, quadrupeds, and cetaceous animals. The females of quadrupeds have a matrix,  
separated



separated into two cavities, *uterus bicornis*, and a considerable number of teats; they have not the menstrual flux; most of them bear several young at a time; the time of their gestation is shorter; several have a peculiar membrane to receive the urine of the fœtus; this membrane is called allantoïdes.

The generation of birds is very different. The males have a very strong and imperforated genital organ, which is often double. The vulva, in females, is placed behind the anus; the ovaria have no matrices; and there is a duct, for the purpose of conveying the egg from the ovarium into the intestines; this passage has been called *oviductus*. The egg of pullets has exhibited unexpected facts to physiologists, who have examined the phenomena of incubation. The most important discoveries are those of Malpighi and Haller. The latter found the chicken, perfectly formed, in eggs which were not fecundated.

There is no determinate conjunction among fishes; the female deposits its eggs on the sand, over which the male passes, and emits its seminal fluid, doubtless for the purpose of fecundating them; these eggs are hatched after a certain time.

The males of several oviparous quadrupeds have a double, or forked organ. Among serpents, the viper is not viviparous.

Insects alone, exhibit all the varieties  
which

which are observed in other animals. There are some, and indeed the greater number, which have the sexes in two separate individuals; among others, the re-production is made either with or without conjunction, as in the vine-fretter, Puceron; one of these insects, confined alone beneath a glass, produces a great number of others. Mr. Bonnet has established this fact, by experiments very carefully repeated. The organ of the male is inclosed in the abdomen, and may be caused to appear, by lightly pressing the extremity of this part. It is usually armed with two hooks, to seize the female. The place of these organs is greatly varied; with some it is at the upper part of the belly, near the breast-plate, as in the female of the dragon-fly; in others, it is at the extremity of the antenna, as in the male spider. Insects multiply prodigiously, and are almost oviparous, except the wood-louse.

Worms are hermaphrodites; each individual has two sexes, and the conjunction is double, as is observed in the earth-worm and the snail.

Mr. Adanson adds, that bivalves, shell animals, or concha, have no organs of generation, and reproduce their young without conjunction; these worms are viviparous. Univalves, or snails, are oviparous; the small animals, whether they issue from the belly

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of the mother, or from eggs, have their shell ready formed.

Polypi are the singular animals, with respect to generation; they are reproduced by buds, or offsets: a bud is separated from each vigorous polypus, which is fixed to some neighbouring body, and grows: polypi are likewise found on their surface, in the same manner as branches issue from the trunks of trees.

The mere phenomena of generation compose the whole of our knowledge of the subject; and all the systems invented to explain this mystery are attended with insurmountable difficulties: they may be seen collected in the Physiology of Haller, the Venus Physique of Maupertuis, and the Natural History of Buffon. Mr. Bonnet has treated largely on this subject, in his considerations on organized bodies. M. De Buffon has given an ingenious system, which may be seen in his work.

VII. Irritability is the property which certain organs, called muscles, possess of contracting or shortening, by the action of any stimulus which touches them. Mr. Haller has proved this valuable doctrine in the most perspicuous manner. The muscles of man, of quadrupeds, of cetaceous animals, and of birds, resemble each other; they are all alike red, composed of fibres, united in bundles of different forms, covered with silver-coloured

loured membranes, called aponeuroses, and terminated by flat, or round cords, named tendons.

The muscles of fishes are white, and much more irritable than those which are red. The irritability in oviparous quadrupeds and serpents is still stronger, and lasts a long time after the death of the animal. This appears to be a common property in all animals whose blood is cold; whereas, in animals which have warm blood, it disappears in proportion as that fluid cools.

Insects have their muscles placed within their bones, which are hollow, and of the nature of horn. This structure may be well observed in the hollow thigh of the large green grasshopper, and may likewise be easily observed in the lobster.

The muscles of worms are very pale, and irritable; they are likewise very strong in covered worms, which have a heavy shell to carry.

Polypi are very irritable; they contract into a single point, and move their arms with singular agility; yet their structure does not appear to be muscular.

It is from the property of irritability that animals possess the power of transporting themselves from place to place, and of performing a great number of motions, to remove noxious things, and to obtain those which are useful. The history of this func-

tion ought, therefore, to include that of animal motions. Standing, walking, leaping, flying, creeping, or swimming, are combined actions, or the results of muscular contractions, in each class of animals. An explanation of these, would require a description of the extensor muscles of the thigh of man, for standing; that of the extremities of the figure of the body; the long and acute face, and the thorax, laterally compressed, in quadrupeds, for leaping; of the structure of the feathers, the sternum, the pectoral muscles, the beak, the tail, and the interior texture of the bones, of birds, for flying. In this history, likewise, it would be necessary to consider at large, the muscular annuli, the scales, or the tubercles, which answer the purpose of feet in reptiles; the form of the body, the structure of the fins, of the air-bladder, and its communication with the stomach, in fishes; and in insects, the structure, number, and position of the feet, the appendices of the tarsus, the form, position, and nature of the wings, the ballancers, &c. But it is sufficient, in this place, to have shewn the importance of these considerations, and such as peculiarly deserve the attention of the physiologist.

Lastly, there is another consideration, which does not appear to have been sufficiently attended to; namely, that a muscle may be regarded as a secretory organ, appropriated

priated to the separation of the fibrous and irritable matter, of which we shall elsewhere speak; and that the imperfections of this kind of secretion ought to be very carefully observed by physicians. We shall resume this subject in our examination of the blood.

VIII. Sensibility is a function, by means of which animals experience the sensations of pleasure and pain, according to the nature of the bodies which are in contact with their organs. The senses depend on the brain, the medulla allongata, the spinal marrow, and the pairs of nerves, which issue in great numbers from these three foci; without these organs, sensibility could not exist. In order to understand the mechanism of this function more readily, we may divide into three regions, those organs which are continued, and seem to form but one, which physiologists have called the sensible man: these three regions consist of the brain, the cerebellum, and the medulla allongata; the middle or part of communication consists of the nervous fibres, and the sensitive expansion, or dilated extremity, of the nerves. This extremity exhibits various forms in different organs; in some it is membranous and reticular, as in the stomach and intestines; in others, it is soft and pulpy, as at the bottom of the eye, and in the labyrinth of the internal ear: in some situations, it has the form of papillæ, as beneath the skin, on the

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tongue,



tongue, and on the glands, &c. and in others it is spread into long, soft, and flat fibres, as in the nasal membrane of Schneider.

The brain in man is larger and better organized than in other animals, and is the cause of his understanding. In quadrupeds it is much smaller; but on the other hand, their nerves are more sensible, and their senses more acute, especially that of smell, the organ of which is much dilated, and as it were multiplied, by the number of ethmoidal laminæ. Their thick hairy skin deprives them, in a great measure, of the sense of touch; but their taste is very acute. The ear has the same apparatus, as in man.

Cetaceous fish have scarcely any brain, in proportion to the mass of their bodies; this organ is surrounded with an oily and thick fluid; their senses are obtuse.

The brain of birds has neither the same structure nor the same apparatus of folds, eminences, and concavities, as that of man and quadrupeds. The beautiful structure of the eyes of these animals, their magnitude, the thick and cartilaginous sclerotica, the internal eye-lid, or *membrana nictitans*, moved by peculiar muscles, the mass of the crystalline and vitreous humours, the vessel of black matter contained at the extremity of the optic nerve, the brilliant colour of the choroides, all denote a complicated organization, and a peculiar care taken by nature to

to render the sight of birds penetrating; that they may see their prey at a great distance, and avoid the dangers which the rapidity of their flight would otherwise have continually led them into; and, in a word, to promote that agility and quickness of motion, which appear to be the lot of these animals. Their smell is less perfect than their sight; they do not appear to be very sensible of the smell and taste of food; the situation of the apertures of the nostrils, and the hard membrane which covers the beak, serve to explain these phenomena with sufficient facility.

Among reptiles the sensibility is not very considerable. The brain is very small, and the nerves have no ganglions; the senses, in general, do not appear to be active, though the eye, and internal ear, presented a very beautiful organization to Messrs. Klein, Geoffroy, and Vicq d'Azyr.

Fishes have a very small brain, and their cranium is filled with an oily matter. Their senses, more especially their sight and hearing, are of considerable delicacy. The organ for the latter of these senses is very well formed, as Messrs. Klein, Geoffroy, Camper, and Vicq d'Azyr have observed. Such naturalists as have supposed fishes to be deaf, appear therefore to be mistaken.

Insects have no brain, but a lengthened medullary substance, of a cylindric form,

full of nodules, which occupies the whole length of their body. From this substance issue nervous fibres, which accompany the division of the trachea. The eyes of insects are known. Swammerdam has described an optic nerve, which is divided in such eyes as have the appearance of network, into as many fibres as there are facets in that membrane. It is not known whether they have an organ of hearing.

Few or no traces of the sensible organ are perceived in worms. Swammerdam found in the snail a brain moveable and with two lobes, eyes placed either on the base or at the point of the tentacula, and an optic nerve, contractable like those kind of horns. Mr. Adanson affirms, that eyes are sometimes either wanting in worms, or that they are covered with an opaque skin.

As to polypi, they have no organ of sense, though they appear to seek the light.

Sensibility is therefore a function enjoyed by man in a much stronger degree than by other animals. It is this which distinguishes him, and places him at the head of the animated creation; and this function requires to be carefully and minutely inquired into, by the legislator, the philosopher, and the physician.

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C H A P. IX.

Concerning the Chemical Analysis of Animal Substances in general.

**T**HE analysis of animal substances is a part of chemistry, which is the most difficult, and least advanced of any. The ancient chemists contented themselves with distilling these substances by a naked fire; an operation which is now known to alter, and intirely change bodies of so compounded a nature as the solids and fluids of animals. Some of the fluids of the human frame, and of certain quadrupeds, only have been subjected to this analysis.

Many causes oppose the advancement of this branch of chemistry; the difficulty and unpleasantness of these experiments, the small number of expedients for the treatment of animal matters, without changing them very much, the impossibility of finding the most remote synthetical method of reproducing these matters, and more particularly the uninteresting nature of these researches to chemists who are not physicians, are the principal motives which have hitherto impeded the progress of science respecting them.



them. Nevertheless, the researches of certain modern philosophers, especially Messrs. Rouelle, Macquer, Bucquet, Poulletier de la Salle, Berthollet, Proust, Scheele, and Bergman, have opened a new path, and shew that the art of healing may receive the greatest advantages from inquiries of this nature.

The bodies of the principal animals, such as man and quadrupeds, to which our attention is particularly directed, are formed of fluids and solids. The fluids of animals are distinguished into three classes, relative to their uses. The first class contains the recrementitial humours, designed to nourish and support certain organs. The second comprehends the excrementitial humours which are excluded out of the body, by certain emunctories, as useless, and capable of producing noxious effects, if retained too long. In the third are ranked, such as are of the nature of the two preceding, being partly recrementitial, and partly excrementitial: the former are the blood, the lymph, the jelly, the fibrous or glutinous part, the fat, the marrow, the matter of internal perspiration, and the osseous juice; the latter comprehends the fluid of insensible transpiration, the sweat, the mucus of the nostrils, the cerumen of the ears, the gummy matter of the eyes, the urine, and the fæces. These last are the saliva, the tears, the bile, the pancreatic juice, the gastric and intestinal

tinal juices, milk, and the seminal liquor. We cannot examine all these fluids in the order we have enumerated them; 1. Because they are very little known; 2. Because it is indispensably necessary to treat of those, in the first place, whose analysis is the most advanced.

The solids of animals, which form the parenchyma of their different organs, may be divided into three classes; the first containing soft and white parts, as the laminæ of the cellular tissue, the membranes, the membranous viscera, the aponeuroses, the ligaments, the tendons, and the skin. The soft and red parts form a second class, very distinct from the first; such, in particular, are the muscles, and a part of those organs which contain muscular fibres, such as the stomach, the intestines, the bladder, the matrix, &c. Lastly, the third class comprehends the bony solids.

The animal analysis is at present very different from that formerly used. The decomposition by fire is now no longer practised, and animal matters are treated with re-agents, more especially acids, alkalis, spirits of wine, &c. The different fluids, mixed with each other, or contained in the vesicles of the different parts, are separated by repose, by decantation, by filtration, or by expression. The action of these substances on colouring matters is examined, as well as the several

several changes they undergo at different temperatures. By careful evaporation of animal liquors, the different salts they contain are separated without alteration.

By these methods of analysis, modern chemists have made many important discoveries. Scheele has discovered several acids different from all those before known. M. Berthollet has ascertained the existence of disengaged phosphoric acid in urine, and in sweat; he has likewise found a very considerable quantity of mephitic in animal matters. This last discovery is one of the most important parts of the animal analysis; the presence of mephitic, in these substances, and especially in the fibrous parts, explains the difference which exists between them and vegetable matters. To obtain this elastic fluid, muscular flesh must be treated with the nitrous acid; a considerable quantity is disengaged, even without the assistance of external heat. This mephitic passes before the nitrous air, and the receiving vessels must be changed as soon as the latter begins to appear.

By this discovery, M. Berthollet explains the formation of volatile alkali, afforded by animal substances, subjected to the action of fire, and also the production and disengagement of this salt by putrefaction; together with the relation or resemblance of these substances with vegetable matters, which  
putrefy,

putrefy, and afford volatile alkali by distillation. It appears, in fact, that this alkali is formed, in both cases, by the combination of inflammable gas with mephitic. I cannot do better than quote, in this place, the words of M. Berthollet on the general nature of animal substances, in a memoir read at a public meeting of the Faculty of Medicine, and inserted in the *Journal de Physique*, Vol. XXVIII. Page 272.

“ Organized bodies are principally composed of two substances, which have very evident distinctive characters: the one affords acid, when decomposed by the action of fire, and the other volatile alkali; the one forms ardent spirit, by fermentation, the other putrefies immediately, and affords volatile alkali; the one, by calcination, affords a coal, which burns readily, the other is reduced into a coal of difficult combustion: lastly, the former compose the greatest part of vegetable, and the latter of animal, substances; whence they are distinguished by the two denominations.

“ M. Bergman formed, by means of sugar and the nitrous acid, an acid which he called the saccharine acid, and which possesses remarkable properties. I applied this kind of analysis by the nitrous acid to animal substances, and I found that they all afforded a greater or less quantity  
“ of



“ of saccharine acid, but always accompa-  
“ nied with a peculiar oil. I observed that  
“ no ammoniacal salt was obtained, but  
“ that a residue was afforded, which is not  
“ found in vegetables. From these first  
“ experiments I concluded (*Memoires de*  
“ *l'Academie*, 1780) that animal substances  
“ contained a substance analogous to sugar,  
“ united to an oil, which I considered as  
“ peculiar to animal substances. My ex-  
“ periments likewise informed me, that the  
“ volatile alkali did not exist in animal sub-  
“ stances, but that it arose from a combi-  
“ nation formed either by the action of heat,  
“ or the influence of putrefaction; and  
“ lastly, the residue concerning which I  
“ did not explain myself in that memoir,  
“ contains phosphoric acid in excess, com-  
“ bined with calcareous earth.

“ I afterwards examined the action of  
“ lime and metallic salts on animal sub-  
“ stances, and proved, that this action in  
“ which their causticity consists, is a con-  
“ sequence of the chemical affinities of the  
“ metallic calces, which tend with various  
“ degrees of force to become revived; so  
“ that those which are very easily revived,  
“ such as the calces of silver and of mer-  
“ cury, have a strong degree of causticity,  
“ and form very caustic salts. Hence  
“ it follows, by applying the modern dis-  
“ coveries of philosophers to the theory I  
“ have

“ have given, that it is the air combined in  
“ metallic calces, and deprived of the prin-  
“ ciple of elasticity, which tends to unite  
“ with a principle of animal substances,  
“ and this principle appears to me to be  
“ the oil they contain; but the causticity  
“ of alkalis cannot be attributed to the same  
“ cause, but must be the effect of another  
“ affinity. I have proved in the Memoirs  
“ of the Academy for the year 1782, that  
“ the caustic alkali dissolved animal sub-  
“ stances without disuniting their princi-  
“ ples. I have shewn the properties of  
“ this combination, and have availed myself  
“ of it to unite the animal substances with  
“ different metallic calces; several combi-  
“ nations were produced, which were be-  
“ fore unknown to chemists; but the cauf-  
“ tic alkali treated in the same manner with  
“ vegetable substances formed no combina-  
“ tion.”

“ By pursuing my inquiries, I have suc-  
“ ceeded in determining the principles of  
“ the volatile alkali. I have shewn, that  
“ the volatile alkali is a combination of  
“ detonating inflammable gas, or, to speak  
“ more accurately, of the inflammable gas  
“ of water and phlogisticated air, or me-  
“ phitis: so that the inflammable gas forms  
“ nearly the sixth part of the weight, or  
“ two-thirds of the volume of the volatile  
“ alkali. I have since determined how the  
“ volatile

“ volatile alkali is produceable by putrefac-  
“ tion, or by the action of fire. All mat-  
“ ters which have the character of animal  
“ substances contain mephitic, which may  
“ be abundantly separated by means of the  
“ nitrous acid. It must necessarily happen,  
“ therefore, when these substances are dis-  
“ tilled, that their mephitic must pass into  
“ some combination, or that it will be found  
“ among the aeriform products; but it is  
“ not found in these last, as I have ascer-  
“ tained, by detonating the inflammable gas  
“ obtained by this method in the eudiometer  
“ of M. Volta, and comparing it with the  
“ inflammable gas obtained by the distilla-  
“ tion of charcoal, and that of vegetable  
“ substances; and there is nothing among  
“ the other products of the distillation but  
“ the volatile alkali, which can have re-  
“ ceived it into its composition. Conse-  
“ quently, whenever volatile alkali is form-  
“ ed, the mephitic of the animal substances  
“ combines with the inflammable gas, which  
“ is separated from the oil, or most proba-  
“ bly with that which arises from the de-  
“ composition of the water, whose vital air  
“ at the same time combines with the char-  
“ coal to form fixed air. In putrefaction,  
“ the inflammable gas combines with the  
“ mephitic; whereas in the spirituous fer-  
“ mentation, the same gas combines with  
“ a vegetable oil and sugar, to form spirit  
“ of

“ of wine, in which I have found and separated these substances, by means of the dephlogisticated marine acid.

“ From these several observations it follows, that animal substances are much more compounded than substances which are purely vegetable. They contain a matter analogous to sugar, a peculiar oil, phosphoric acid combined with a small quantity of calcareous earth, mephitic, and very probably fixed air. It is the phosphoric acid which exists in the coal of animal substances, combined with a portion of the true charcoal, of the oil, and with earth, that appears to me to constitute the difference observed to exist between the coals of animal substances and those of vegetables.”

Such is the clear and perspicuous manner in which M. Berthollet conceives and explains the general nature of animal substances. When these accurate results are compared with the vague notions hitherto exhibited respecting the difference between vegetable and animal matters, we are astonished at the progress which chemistry has made of late years, by the researches of the Swedish and French chemists. There is every reason to think, that a connected series of inquiries into the nature of animal matters, according to the plan sketched out by the most celebrated chemists from the time of Margraaf



graaf and Rouelle to the present, would afford many valuable particulars of information respecting their formation, alterations, and destruction; and would be more particularly useful in the art of medicine. The application of the discoveries already made, which we shall exhibit in the following chapters, will place this assertion beyond all doubt.

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## C H A P. X.

### Concerning the Blood.

**T**HE blood is the most important, the most compounded, and the most impenetrable of the recrementitious humours. We shall treat of it in the first place, because, according to the doctrine of the greatest physicians, it is the source and focus of all the other animal fluids. Many physicians, and particularly Mr. Bordeu, considered it as a kind of fluid flesh, and as a compound of all the animal humours. This opinion is not intirely proved, though it is very probable.

The blood is a fluid of a beautiful red colour, and an unctuous fat consistence, as it were saponaceous, of an insipid and rather  
saline

saline taste, which is contained in the heart, the arteries, and the veins. This fluid differs greatly, according to the regions through which it passes; it is not, for example, the same in the arteries, and in the veins, in the stomach, and in the region of the liver, in the muscles, and in the glands, &c. This fact has not been sufficiently attended to by chemists.

When we consider the blood, with respect to the whole animal kingdom, we may observe that it varies remarkably in different animals, with respect to colour, consistence, smell, and more especially temperature. This last property is the most important, and appears to depend on the circulation and the respiration. The blood of men, quadrupeds, and birds, is hotter than that of the medium they inhabit; they are therefore called animals with warm blood. In fishes and reptiles it is nearly of the temperature of the medium they inhabit; for which reason they are called animals with cold blood. It is probable, that differences equally considerable would be found to obtain in all the other properties of this fluid, and especially the chemical qualities or characters, if the blood of all animals were properly examined.

The blood of man, to which our attention is particularly directed, differs according to the age, sex, temperament, and state of

health of the individual: in infancy, in the female sex, and in consumptive persons it is paler, and thinner; in robust and healthy men it is thicker, of a deeper colour, almost black, and of a much more saline taste.

Before we proceed to the analysis of blood, it will be proper to speak of its physical properties; namely its colour, temperature, taste, smell, and peculiar consistence, which we have already mentioned. The microscope discovers a great number of globules, which, when broken, according to Leuwenhoek and Boerhaave, by passing through the smaller passages, lose their red colour, become yellow, and afterwards white; so that, according to the physician of Leyden, a red globule is an assemblage of many smaller white globules, and owes its colour to its aggregation only. The blood likewise presents remarkable physical properties: while hot, and in motion, it remains constantly fluid and red; when it cools at rest it takes the form of a solid mass, which gradually and spontaneously separates into two parts; the one red, which floats above, whose colour becomes deeper, and which remains concrete, till it is altered by putrefaction; the other, which occupies the lower part of the vessel, is of a yellow greenish colour, and adhesive: it is called serum or lymph. This coagulation and spontaneous  
separation

Separation of the two parts of the blood takes place at the last moments of the life of the animal, and produces those concrete substances which are found in the heart and the large vessels, and have been falsely taken for polypi. Blood exposed to a gentle heat long continued, undergoes the putrid fermentation. By distillation on the water-bath, it affords phlegm of a faint smell, which is neither acid nor alkaline, but readily putrefies by virtue of an animal substance it holds in solution. Blood heated more strongly, coagulates, and gradually dries, as De Haen has discovered, losing seven-eighths of its weight, and effervescing with acids. By a well managed fire, it hardens into a kind of corneous substance. If dried blood be exposed to the air, it slightly attracts humidity, and at the end of some months a saline efflorescence is formed, which Rouelle found to be salt of soda. By distillation with a naked fire, it affords an alkaline and partly acid phlegm; that is to say, in the state of sal-ammoniac, super-saturated with alkali. The nature of this empyreumatic acid, first perceived by Wieussens, and which has excited such disputes among physiologists, has not yet been properly examined. A light oil afterwards comes over; next a coloured and ponderous oil, and concrete volatile alkali, or ammoniacal chalk, contaminated by the thick oil; a spongy coal remains in the



retort, which is very difficult to incinerate, and contains sea salt, cretaceous soda, iron, and a substance apparently earthy, which is found to be calcareous phosphate.

Blood united to alkalis becomes more fluid by standing. Acids immediately coagulate it, and change its colour. By filtration, and evaporating of the filtrated liquor to dryness by a gentle fire, and subsequent lixiviation of this residual matter, such neutral salts are obtained, as salt of soda forms with each acid; any of which may be indiscriminately used. Spirit of wine coagulates blood.

Experiments made on blood in its original state, do not shew the nature of the substances which compose this fluid; but the spontaneous decomposition of blood, and the separation of its two parts, the clot and the serum, afford a method of performing this by examining each substance in particular. Till within a few years, the chemical analysis of blood was confined to what has been related in the foregoing pages. Messrs. Menghini, Rouelle the younger, and Bucquet, have examined this fluid in a very different manner. They have made experiments with this substance, which shew how nearly the analysis of animal matters is capable of being brought to perfection by following their steps. From the researches of these learned men, we shall proceed to consider

sider the properties of each of the substances which compose blood,

The serum, far from being pure water, is a peculiar matter of great importance to be considered, and to which we give the name of the albuminous fluid. It is of a yellowish white, inclining to green; its taste is dull and saline; its consistence unctuous and adhesive. When exposed to heat, it coagulates and hardens long before it boils. It converts syrup of violets to a green. When distilled on the water-bath, it affords a mild and insipid phlegm, neither acid nor alkaline, but subject to putrefaction: the matter in the retort is then dry, hard, and transparent like horn, and no longer soluble in water; but by a strong heat it affords an alkaline phlegm, much concrete volatile alkali, and a very fetid oil. All these products in general have a peculiar fetid smell. The coal of serum distilled by a naked fire, almost intirely fills the retort. It is so difficult to incinerate, that it requires to be kept red hot for several hours, with a large surface exposed to the air, before it can be reduced to ashes. The ashes are of a blackish grey, and contain marine salt, chalk of soda, and calcareous phosphate.

Serum exposed for a certain time to a warm temperature in an open vessel, passes quickly to putrefaction, and then affords much concrete volatile alkali of an abomi-

nable smell. It putrefies so rapidly, that Bucquet could not decide whether it passes to acidity before it becomes alkaline. This fluid unites with water in all proportions, and then loses its consistence, its taste, and its greenish colour; the mixture must be agitated, in order to promote the union of the two fluids, which are kept apart by their different densities. Serum poured into boiling water, for the most part coagulates instantly. A portion of this fluid forms with water a kind of white, opaque, and milky fluid, which, according to Bucquet, has all the characters of milk; that is to say, it affords cream, coagulates by heat, by acids, &c.

Alkalis added to serum, render it more fluid by a kind of solution. Acids change it in an opposite manner, by giving it consistence, and by coagulating it. This last mixture being filtrated, and the fluid evaporated, the neutral salt which the acid made use of forms with soda, is obtained; which proves, that this last salt existed in a disengaged state, and possessed of all its properties, in the serum. The coagulation formed in this liquor by the addition of an acid, dissolves very quickly in volatile alkali, which is the true solvent of the albuminous part; but it is not all soluble in pure water. Acids precipitate this substance united to the volatile alkali. The coagulation distilled  
by

by a naked fire affords the same products as dried serum, and its coal contains much cretaceous soda; which proves, according to Bucquet, that there is a portion of this salt so intimately combined in the serum, as not to be saturated by the coagulating acid.

The serum, in its dense state, affords mephitis by the action of the nitrous acid on the application of a gentle heat. If the heat be raised, nitrous gas is disengaged from the mixture; the residue affords the acid of sugar, and likewise a small quantity of the peculiar acid, called malusian acid, by M. de Morveau. (See the Preliminary Dissertation at the commencement of our first volume, page lxxxviii).

Serum does not decompose the calcareous and argillaceous neutral salts; but it decomposes metallic salts very readily. It is coagulable by spirit of wine, and this coagulation differs greatly from that which is formed by acids, more particularly in its solubility in water, as Bucquet has discovered. This liquid therefore appears, from these experiments, to be an animal mucilage composed of water, acidifiable oily bases, marine salt, chalk of soda, and calcareous phosphate; this last appears to produce the rose-coloured precipitate, which I have obtained by pouring the nitrous solution of mercury into serum. Though the liquid be scarcely coloured,



the addition of nitrous acid, and more especially of mercurial nitre, produces a rose or light flesh colour, which I have frequently observed in many other animal liquors. The most singular property of this mucilage, which deserves the attention of physicians is, its becoming concrete by the action of fire, and of acids. Mr. Scheele thinks that this phenomenon arises from the combination of heat.

The clot of blood exposed to the heat of a water-bath, affords an insipid water, and becomes dry and brittle. By distillation it affords an alkaline phlegm, a thick oil of a fetid and empyreumatic smell, and much volatile alkali. Its residue is a spongy coal of a brilliant and metallic aspect, difficult to incinerate, and which when heated with the vitriolic acid affords vitriols of soda and of iron. After these operations, a mixture of calcareous phosphate and coaly matter remains. The clot of blood putrefies very quickly in warm air. When washed with water, it is separated into two very distinct substances, one of which is dissolved, gives the fluid a red colour, and the solution, when heated with different menstrua, exhibits all the characters of serum; but it contains a much greater quantity of iron, which may be obtained by incineration of the coal, and subsequent washing, to separate the saline matters. The residue of this washing is  
saffron

saffron of Mars, of a beautiful colour, and usually attracted by the magnet. The colour of blood is attributed to this metal. Iron has been obtained from blood in considerable quantities, by Menghini, Rouelle, and Bucquet.

The clot, after having been washed, and deprived of all its red serum, appears to consist of a white fibrous matter, which remains to be examined.

The fibrous part of the blood is white, colourless, and insipid, after it has been well washed. By distillation on the water-bath, it affords a tasteless phlegm of a faint smell, and capable of putrefaction. The most gentle heat singularly hardens the fibrous matter: when suddenly exposed to a strong heat, it shrinks up like parchment. By distillation in a retort, it affords an alkaline phlegm, a ponderous, thick, and very fetid oil, with much ammoniacal chalk contaminated by a portion of oil. Its coal is not bulky, but compact and heavy, and is less difficult to incinerate than that of the lymph. Its ashes are very white, and contain neither saline matter nor iron; which doubtless were carried off by the previous washing: the appearance of these ashes is earthy, and they seem to consist of calcareous phosphate.

The fibrous part in the blood putrefies very quickly, and with great facility; when exposed to a hot and moist air, it swells,  
and

and affords much volatile alkali. It is not soluble in water; when boiled with that fluid it hardens and assumes a grey colour. Alkalis do not dissolve it; the most feeble acids combine with it. The nitrous acid disengages much mephitic, as Mr. Berthollet has observed, and afterwards dissolves it with effervescence, and disengagement of nitrous gas; when all this gas is disengaged, oily and saline flocks are observed in the residue, which float in a yellowish liquor; by evaporating this liquor crystals are obtained, analogous to the acid of sugar, or oxaline acid (see the Additions to the Vegetable Kingdom), and a considerable quantity of flocks formed of a peculiar oil and calcareous phosphate is deposited. There seem to be two oils in the fibrous part; one, which, with the oxygenous principle, constitutes the oxaline acid; the other, which with the same principle, forms the malusian acid.

The fibrous matter is likewise soluble in the muriatic acid, which causes it to assume the form of a green jelly. The acid of vinegar dissolves it with the assistance of heat: water, and more particularly alkalis, precipitate the fibrous matter when dissolved in acids. This animal substance is decomposed in these combinations; and when separated from the acids by any method, it no longer presents the same properties.

The neutral salts, and other mineral substances,

stances, do not act upon it. It unites to the lymph, especially that which is coloured, to form the clot. This last, like the fibrous part, is totally soluble in acids; doubtless, on account of the combination of this matter with the red serum. Hence we see, that the fibrous part differs greatly from the albuminous matter. It is a substance more perfectly animalized than this last; a kind of animal gluten, which greatly resembles that of flour; and which more especially possesses the remarkable property of becoming concrete, by cooling and rest. It cannot be doubted, but that this matter, which has not hitherto been distinctly observed by physiological and pathological physicians, is of the greatest consequence in the animal economy. I have long since observed, that it is deposited in the muscles, constituting the fibrous base of these organs, and that it forms the substance which is most eminently irritable. Whence I have inferred, that it is of consequence to pay a greater attention to this substance than has hitherto been done; and to consider it as capable by its abundance or deviation of causing peculiar disorders. And I have exhibited the proofs of these useful medical considerations in a Memoir, which will be inserted in the volume of the Royal Society of Medicine for the year 1783, &c.

Notwithstanding these researches into the  
nature



into the nature of blood, much remains to be done before its chemical properties will be perfectly known. The intimate difference between the serum and the fibrous part is yet unknown: neither has blood been yet examined in all its states; especially in the different disorders which considerably alter this fluid; as for example, in strong inflammations, in the chlorosis, scorbutic disorders, &c. Physicians judge of these alterations merely by the external appearance, and it is much to be wished that their nature were better ascertained by accurate analysis.

Rouelle has examined the blood of several quadrupeds, such as the ox, the horse, the calf, the sheep, the hog, the ass, and the goat; he obtained the same products as from the human blood, but in different proportions.

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## C H A P. XI.

### Concerning Milk.

**M**ILK is a recrementitial humour designed to nourish young animals in the early part of their life. It is of an opake white colour, a mild saccharine taste, and a slightly aromatic smell. It is separated immediately

immediately from the blood in the breasts or udders of the female animals, to which it is conveyed principally by the arteriæ mammariæ. Man, quadrupeds, and cetaceous animals, are the only creatures which afford milk. All other animals are destitute of the organs which secrete this fluid.

Milk differs greatly in the several animals; in the human species it is very sweet or saccharine; the milk of the cow is mild, and its principles are well connected; that of the goat and ass have a peculiar virtue, as they are often slightly astringent. The variable properties of milk depend usually on the food of the animal.

Cows milk, which is taken as an example of the analysis, because it is easily procured, is a compound of three different substances, serum, or whey, which is fluid and transparent; butter and cheese, which are more consistent. These three parts are so mixed as to form a kind of animal emulsion.

Milk distilled by the heat of a water-bath, affords a tasteless phlegm of a faint smell, and capable of putrefaction. By a degree of heat somewhat stronger, it coagulates like the blood, according to the observation of Bucquet; by agitation, and gradual drying, it forms a kind of saccharine extract, called franchipane. This extract, dissolved in water, constitutes the whey of Hoffman; the extract distilled by a naked fire affords  
acid,

acid, fluid oil, concreté oil, and ammoniacal chalk. Its coal contains a small quantity of vegetable alkali, febrifuge salt, and calcareous phosphate.

Milk, when exposed to a hot temperature, is capable of undergoing the spirituous fermentation, and forming a kind of wine; but it is necessary that the quantity should be large. The Tartars prepare a spirituous liquor with mares milk. Milk quickly becomes acid, and coagulates. The caseous part becomes solid, and the serum separates.

Acids immediately produce the same effects on milk; they coagulate it, but alkalis, more especially the volatile alkali, re-dissolve this coagulum. Boerhaave affirms, that milk, when boiled with oil of tartar, becomes first yellow, afterwards red, and of the colour of blood. He even thinks, that it is a similar combination, which causes the milk to be converted into true blood in the human body. Neutral salts, sugar, and gum, likewise coagulate milk by the assistance of heat, according to the observation of Scheele.

To prepare whey, milk is heated, and twelve or fifteen grains of rennet is added to every pint. This substance, formed by the mixture of milk, turned sour in the stomach of calves, and of the gastric juice, is a ferment which coagulates the caseous part. When the coagulation is made, the whey is strained from the curd. Gallium,  
the

the flowers of the thistle, and of artichoke, act in the same manner as rennet upon milk. The internal membrane of the stomach of calves, and of birds, dried and pulverized, produces the same effect upon milk; which proves that the coagulation is produced by the gastric juice, dried and contained in the pores of this membrane.

Serum, or whey, prepared in this manner, is turbid; it may be clarified by white of egg, or cream of tartar. When the serum, or whey, is required to be very pure, for the purpose of examining its nature, cream of tartar must not be added.

Whey has a mild taste. When prepared with new milk, it contains a saccharine essential salt, but it soon acquires an acid taste, by the establishment of the acid fermentation. This change is produced by the alteration of a mucilaginous principle, contained in the milk; and it is the development of this acid which occasions the spontaneous separation of the whey from the other substances contained in milk. It is therefore necessary to examine the acid, which is formed in milk, and constitutes fermented whey. It is a well known fact, that milk left exposed in a temperature of seventy or eighty degrees, experiences, in a few days, a fermentation which develops an acid, and separates the butter and cheese. The acid, formed by this fermentation, and  
which



which is as strong as it will be at the end of twelve or fifteen days, has been examined by Mr. Scheele, and is called the galactic acid by M. de Morveau. The following is the process used by Scheele, to obtain it in a state of purity. After having attempted, in vain, to separate the acid by distillation from sour whey, by which he obtained only a small quantity of vinegar, he evaporated the whey to one eighth, after having filtrated it, to separate all the caseous matter. From this he precipitated the animal earth, by lime-water. He then diluted the fluid with three times its weight of water, and separated the lime by the acid of sugar; at the same time taking care that this last acid should not remain disengaged in the solution, which was easily ascertained and prevented, by the addition of successive small portions of lime-water. The sugar of milk, and several other foreign substances, were then separated, by the addition of spirit of wine, which easily dissolves the acid of milk. Lastly, the decanted solution being distilled, the spirit of wine passed over, and the pure galactic acid remained in the retort. Scheele has observed the following properties in this acid.

When strongly evaporated, it did not afford crystals, but attracted the humidity of the air: by distillation, it afforded an empyreumatic acid, resembling spirit of tartar;  
a small

a small quantity of oil, and a mixture of cretaceous acid and inflammable gas.

With the three alkalis, and also with ponderous earth and lime, it forms deliquescent salts. Its combination with magnesia crystallizes, but likewise attracts the moisture of the air. It does not at all attack cobalt, bismuth, antimony, mercury, silver, or gold, even by the heat of ebullition. It dissolves zink and iron, producing inflammable gas; the first of these salts, called by Morveau the galacte of zink, crystallizes; the second, or the galacte of iron, forms a brown deliquescent mass. The galactic acid calcines, and dissolves copper and lead. The galactic solution of the latter metal deposits a small quantity of vitriol of lead, which indicates the presence of a small quantity of vitriolic acid in this animal acid. Lastly, it decomposes the acetous salt of pot-ash; a property which, together with most of those here mentioned, denotes, as M. de Morveau observes, that the galactic acid differs from vinegar. M. Scheele adds, likewise, that a true vinegar may be obtained from milk, by mixing six spoonfuls of spirit of wine with three pints of milk, and suffering the mixture to ferment in a well-closed vessel. The gas, which is disengaged during this fermentation, must be suffered to escape, from time to time; and at the end of a month the milk is changed

into good vinegar, which may be strained through a cloth, and preserved in bottles. This celebrated Swedish chemist likewise adds, that milk, in a bottle whose neck is plunged in a vessel filled with the same liquor, and exposed to a heat somewhat stronger than that of summer, undergoes a fermentation which affords a large quantity of elastic fluid. This last fluid displaces the milk, and almost intirely empties the bottle, at the end of two days. The acid produced in this fermentation, which takes place without the contact of air, appears to receive its oxygenous principle, or acidifying base of the air, from the decomposition of the water.

The serum of milk, or whey, made by means of rennet, and not yet become sour, holds in solution a certain quantity of a saline substance, known by the name of salt, or sugar of milk. Though Kempfer affirms that the Brachmans were acquainted with the process for preparing this salt, it appears that it was first mentioned by Fabricius Bartholet, or Bartholdi, an Italian physician, in the year 1619. Etmuller, Testi Werloschnigg, Wallisnieri, Fickius, and Cartheuser, have successively spoken of this substance, and described the methods of obtaining it. Messrs. Vulgamoz and Lichtenstein have very well described the method of obtaining this saline substance, which is prepared

pared in large quantities in several parts of Switzerland. The whey obtained from skimmed milk, coagulated with rennet, is evaporated to the consistence of honey; after which it is put into moulds, and dried in the sun. This is the sugar of milk in cakes, and is dissolved in water, clarified with whites of eggs, evaporated to the consistence of syrup, and crystallized in the cold. By this treatment it affords white crystals, in rhomboidal parallelipipedons; the mother water deposits yellow and brown crystals, which are purified by successive solutions. Mr. Lichtenstein has examined and analyzed the different sugars of milk, which are sold at various prices in Switzerland, and has more particularly distinguished, 1. The sweet sugar of milk, which is of a white colour, obtained from sweet and purified whey. 2. The acedent sugar of milk, obtained from sour whey. 3. The sugar of milk, rendered impure by fat substances; which separate, according to him, in the first crystallization. 4. Sugar of milk, mixed with oil and common salt, which crystallizes the last. 5. Sugar of milk, mixed with fat matter, common salt, and sal-ammoniac. It is adhesive and moist, and affords volatile alkali on the addition of fixed alkali. 6. And lastly, Sugar of milk, mixed with all the before-mentioned substances, and likewise with extractive and caseous matter.



This last is of the consistence of honey, becomes rancid, and is acrid and disagreeable.

Sugar of milk, when very pure, has a slightly saccharine, faint, and as it were earthy taste; it always loses by successive solutions. It is soluble in three or four parts of boiling water; and, according to Scheele, Rouelle, and Vulgamoze, it affords the same products as sugar by distillation. Rouelle obtained from a pound of this salt, by burning it, 24 or 30 grains of ashes; three-fourths of which were febrifuge salt, or muriate of pot-ash, and one-fourth chalk of pot-ash, or mild vegetable alkali. On a red-hot coal, sugar of milk melts, boils up, emits an odour of caramel, and burns like sugar. These properties appear to indicate, that this salt is capable of affording the acid of sugar; and Mr. Scheele has shewn, by his experiments, that it does: but he observed, that a large quantity of spirit of nitre is required for this purpose; that four ounces of sugar of milk afford five grains of saccharine acid; and he has also discovered, that if the residues of sugar of milk be treated by the nitrous acid, and filtrated, in order to crystallize the saccharine acid by evaporation, a white powder remains on the filter; which he found to be a peculiar acid, and named it the acid of sugar of milk. He observed, that it possesses the following properties.

It has the form of a white granulated powder;

powder; two drachms of this salt, very pure, being heated in a glass retort, melted, swelled up, and became black; a brown salt, of a mixed smell of benzoin and amber, sublimed, weighing 35 grains; this salt was acid, soluble in spirit of wine, more difficultly in water, and burned on charcoal. The receiver contained a liquor of a brown colour, and not of an oily nature; eleven grains of charcoal remained in the retort. Cretaceous acid and inflammable gas were disengaged during this distillation. The acid of sugar of milk is very sparingly soluble in water, one ounce of boiling water dissolving only six grains; one-fourth of which was precipitated by cooling. According to M. de Morveau, this acid effervesces with the hot solution of cretaceous vegetable alkali. A crystallized salt was obtained, by cooling, which was soluble in eight times its weight of hot water, and crystallized again by cooling. The salt it formed with the mineral alkali was crystallizable, but required no more than five parts of water for its solution. This acid combines likewise with the volatile alkali; the neutral salt, thus produced, loses its alkali by heat. With ponderous earth, clay, magnesia, and lime, it forms salts, nearly insoluble. It acts but very feebly on the metals, and forms with their calces salts of difficult solubility. It

precipitates the nitres of mercury, lead, and silver, as well as the muriate of lead.

Mr. Scheele, when he first made this discovery, supposed that the white powder, deposited by the saccharine acid obtained from sugar of milk by means of the nitrous acid, was merely a proportion of the calcareous salt, formed by the saccharine acid and a proportion of the lime, which might be contained in that animal salt. But he was soon undeceived, by pouring a small quantity of saccharine acid into a solution of sugar of milk; as the mixture afforded no precipitate. Nevertheless, Mr. Hermstadt, who has published two memoirs in *Crell's Chemical Journal*, the second of which treats particularly of this acid earth, thinks, notwithstanding the experiments of Scheele, that it is a compound of saccharine acid, calcareous earth, and a fat substance. But M. de Morveau, after examining the experiments of this chemist, with his usual accuracy, and comparing them with those of Scheele, has shewn, in the new *Dictionnaire Encyclopedique*, that Mr. Hermstadt has not accomplished his undertaking, and that, even from his own results, the discovery of the Swedish chemist is rather confirmed than destroyed. M. de Morveau has likewise made several ingenious experiments which confirm this assertion. To these accounts we may add, that the acids of milk, and of  
sugar

sugar of milk, do not exist ready formed in sugar of milk, and that this salt contains only the bases, which take the oxyginous or acidifying principle from the nitrous acid. We may likewise observe, that subsequent experiments will probably shew, that the acid of sugar of milk is nothing more than a modification of some other vegetable acid; for every circumstance tends to prove, that the principles of whey are derived from the vegetables on which the animals subsist.

The Baron de Haller has given the following proportions of the sugar contained in the milk of different animals.

Four ounces of sheep's milk, afforded of

|               |          |                  |
|---------------|----------|------------------|
| Sugar of milk | -        | 35 or 37 grains. |
| Goat's milk   | afforded | 47 — 49          |
| Cow's milk    | - -      | 53 — 54          |
| Human milk    | - -      | 57 — 58          |
| Mare's milk   | - -      | 69 — 70          |
| Ass's milk    | - -      | 80 — 82          |

Rouelle has observed, that the whey of cow's milk, from which the sugar of milk has been extracted, takes the form of jelly by cooling; and he consequently admits it to contain gelatinous matter.

Cheese, or the caseous matter, takes the solid form, and is separated from the other constituent parts of milk, by the action of fire, by the acid fermentation, and by the mixture of acids. This matter, when well

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washed,



washed, is white, solid, and as it were fibrous; the action of a gentle heat hardens it. Distillation on a water-bath extracts an insipid phlegm, which putrefies.

Dried cheese, distilled in a retort, affords an alkaline phlegm, a ponderous oil, and much concrete volatile alkali. Its coal is dense, very difficultly incinerated, and does not afford fixed alkali. When this coal is treated with nitrous acid, it is found to contain lime, and the phosphoric acid.

Cheese putrefies in a hot temperature; it swells, emits a nauseous smell, becomes imperfectly fluid, and is covered with a scum, or froth, arising from the disengagement of a very strong-smelling and mephitic gas, which escapes with difficulty from this viscid matter.

Cheese is insoluble in cold water; hot water hardens it. Mr. Scheele has observed, that when it has been precipitated by a foreign acid, boiling water dissolves a part.

Alkalis dissolve it, more particularly the volatile alkali, which, when poured in the quantity of a few drops into milk coagulated by an acid, causes the coagulum quickly to disappear.

The concentrated acids likewise dissolve cheese; spirit of nitre disengages mephitic; but the vegetable acids do not sensibly dissolve it. Its solution in the mineral acids is precipitated

tated by the alkalis, which redissolve it if added in too great a quantity.

The neutral salts, more particularly marine salt, retard its putrefaction.

From all these facts it appears, that cheese is a substance greatly resembling lymph; but as it is not itself soluble in water, it is originally suspended in milk, by virtue of the gelatinous mucilage, and the extractive and saccharine substances contained in that fluid.

Butter is partly separated from milk by rest: it is collected at the surface, but as it is mixed with much serum, and caseous matter, it is more completely separated by strong agitation, in which the art of making butter consists. The serum, from which butter is separated by agitation, retains a portion of this oily substance, and is yellow, sour, and fat; it is called butter-milk. Cream is a mixture of cheese and butter, which is skimmed off the surface of milk that has stood for some time. It is much more difficult of digestion than milk itself. If cream be strongly agitated, it takes the form of froth, and is then called whipt cream.

Pure butter is concrete and soft, of a yellow colour, approaching more or less to that of gold, and of a mild agreeable taste. It melts by a gentle heat, and becomes solid by cooling. When distilled on a water-bath, it affords a phlegm nearly insipid. By  
a stronger

a stronger heat, it affords a very penetrating and strong acid, a fluid oil, and afterwards a concrete coloured oil, of the same penetrating smell as the acid. By rectifying these products, the oil is rendered as fluid and volatile as essential oils. The remaining coal is not abundant. The acid obtained from butter, by distillation, seems to be of the same nature as that of fat, which we shall hereafter mention by the name of the sebaceous acid. It may likewise be obtained in the state of neutral salts, by the addition of lime or the fixed alkalis.

Butter soon becomes sour and rancid in a hot air. Its acid is then developed, and its taste is disagreeable. Water, and spirit of wine, in some measure restore its original taste, by dissolving the acid. The fixed alkalis dissolve butter, and form a kind of soap, which is little known.

Hence we find, that butter is an oily substance, of the nature of the fat vegetable concrete oils.

Fresh butter is mild, temperate, and relaxing. But it readily becomes sour, and in general agrees with few stomachs. Rancid butter, whose acid is developed, is one of the most unwholesome and indigestible of all foods.

Milk is an agreeable food, of considerable use in a great number of cases; it is even one of the most valuable medicines we possess.

sefs. It corrects the acrid humours in disorders of the skin, and of the articulations. It cicatrises ulcers of a good kind. It may be charged with the aromatic parts of plants, and is then an excellent remedy in the pulmonary consumption. All stomachs, however, do not digest milk. Such persons as are inclined to acidities in the first passages, are usually incommoded by it; and in general it ought to be administered prudently. Milk, rendered medicinal, by causing the animal which gives it to take different substances, is often used with success in various disorders.

The milk of different animals have certain peculiar virtues; that of the human species is mild, of a saccharine taste, and is greatly serviceable in the marasmus. The milk of the ass is successfully used in the pulmonary consumption, and the gout: it usually relaxes. Mare's milk resembles that of the ass. Goat's milk is serous, and lightly astringent. Cow's milk is the thickest, the fattest, and the most nourishing; it is likewise the most difficult of digestion, and often requires to be diluted with water, or with some aromatic infusion, especially if it does not easily pass off, or produces costiveness.

Milk is likewise used externally, as a softening and emollient remedy. It mitigates pain, ripens gatherings and abscesses, and hastens suppuration. It is applied hot, and inclosed in a bladder on the diseased parts.

C H A P.



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C H A P. XII.

## Concerning Fat.

**F**AT is a concrete oily matter, contained in the cellular membrane of animals; it is white, or yellowish, with little or no smell or taste, and differs in all animals in its solidity, colour, taste, &c. and likewise in the same animal, at different ages. In infancy it is white, insipid, and not very solid; in the adult it is firm, and yellowish; and in animals of an advanced age, its colour is deeper, its consistence various, and its taste in general stronger. The fat of man, and of quadrupeds, is consistent, white, or yellow. That of birds is finer, sweeter, more unctuous, and in general less solid. In cetaceous animals and fishes, it is almost fluid, and frequently placed in peculiar reservoirs, as in the cavity of the cranium. It is likewise found in serpents, insects, and worms; but in these animals it is only met with among the viscera of the lower belly, on which it is placed in separate portions; being scarcely ever observed but in minute quantities, on the muscles or beneath the skin.

It

It has been observed, that the fat of frugivorous and herbivorous animals is firm and solid, while that of carnivorous animals is more or less fluid. It must, however, be remarked, that the fat is always less solid and concrete, in the warm and living animal, than in the same animal when dead and cold, in the hands of the dissector.

Fats vary, according to the parts of the animal from which they were taken : it is solid near the reins, and beneath the skin ; it is less firm between the muscular fibres, or near moveable viscera, such as the heart, the stomach, and the intestines. It is more abundant in winter than in summer ; it appears destined to maintain the heat in those regions wherein it is placed, as many facts, collected by physiologists, demonstrate. It even appears to contribute to the nourishment of animals, as is observable in bears, the mountain rat, the dormouse, &c. and in general all animals, forced to long abstinence, in which the fat melts, and gradually disappears.

To prepare fat for pharmaceutical purposes, it must be cut in pieces, and the membranes and vessels separated ; it is afterwards to be washed with much water, and melted in a new earthen vessel, with the addition of a small quantity of water ; when this fluid is diffipated, and the ebullition ceases, it must be poured

poured into a glazed earthen vessel, where it fixes, and becomes solid.

Fat has not yet been examined sufficiently to ascertain all its chemical properties. The action of fire, air, and certain menstruums, on this substance, only are known. It is nevertheless highly necessary to be perfectly acquainted with this animal substance, in order to judge of its uses; concerning which nothing is yet certainly known, and more especially the alterations it is subject to in living bodies.

The fat of any animal, exposed to a gentle heat, liquifies, and congeals by cooling. If it be strongly heated, with contact of air, it emits a smoke of a penetrating smell, which excites tears and coughing, and takes fire when sufficiently heated to be volatilized: the charcoal it affords is not abundant. If fat be distilled on a water-bath, an insipid water of a slight animal smell, is obtained, which is neither acid nor alkaline, but which soon acquires a putrid smell, and deposits filaments of a mucilaginous nature. This phenomenon, which takes place with the water obtained by distillation on the water-bath, from any animal substance, proves, that this fluid carries up with it a mucilaginous principle, which is the cause of its alteration. Fat, distilled in a retort, affords phlegm, at first aqueous, and afterwards strongly acid; an oil, partly liquid, and partly

partly concrete; a very small quantity of charcoal, exceedingly difficult to incinerate, in which Mr. Crell found a small quantity of calcareous phosphate. These products have an acid and penetrating smell, as strong as that of the sulphureous acid. The acid is of a peculiar nature, and has been carefully examined by Mr. Crell; but as it is very difficult to obtain by distillation, this celebrated chemist has used a much more certain and expeditious process, which we shall presently describe. The concrete oil may be rectified, by repeated distillation, so as to become very fluid, volatile, and penetrating; in a word, to present all the characters of a true essential oil. Twenty-eight ounces of human fat afforded Mr. Crell twenty ounces five drachms forty grains of fluid oil, three ounces three drachms and thirty grains of sebaceous acid, three ounces one drachm four grains of a brilliant charcoal, considerably resembling plumbago, as M. de Morveau remarks. Five drachms six grains of matter were lost in this analysis, which may be attributed to the water in vapour, and the elastic fluids, because Mr. Crell did not use the pneumato-chemical apparatus.

Fat exposed to a hot air, alters very quickly; the mild, and scarcely sensible smell, is changed to strong rancidity. This alteration appears to consist of a true fermentation,



mentation, by which the acid is developed and disengaged. Though this acid appears to be of the nature of the sebaceous acid, yet I cannot think that the oily part of the fat is the sole cause of the change, but that the peculiar animal mucilage, which subsequent analysis will discover, has also a share in it. Rancid fat may be corrected by two methods: water is capable of carrying off the acid it contains, as Mr. Poerner has observed; spirit of wine has the same property, according to Mr. Machy. This proves, that a part of rancid fat is put into a saponaceous state by its acid, and by that means rendered soluble in water, and in spirit: either of these fluids may therefore be used with success to deprive fat of its rancidity.

When fat is washed with a great quantity of distilled water, the fluid dissolves a gelatinous matter, which may be exhibited by evaporation; but the fat always retains a certain portion of this matter, with which it is intimately combined, and on which its property of fermenting depends. The action of water on this animal substance has not yet been further inquired into.

Messrs. Crell, and the chemists of Dijon, have explained the action of alkaline substances on fat. It has been long since known, that the pure alkalis form a kind of soap with fats. Mr. Crell, by treating soap with  
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a solution of alum, separated the oil, and obtained a solution of the sebaceous salt of vegetable alkali by evaporating the fluid. He distilled this salt with oil of vitriol, which disengaged the sebaceous acid. To deprive this of the portion of vitriolic acid it may be contaminated with, Mr. Crell directs it to be re-distilled from one-fourth of the sebaceous salt of pot-ash, which must be reserved for this use. It may be ascertained that it contains no more vitriolic acid by the addition of the acetous salt of lead: for if the precipitate be totally soluble in vinegar, it does not contain vitriolic acid. The chemists of the academy of Dijon use a more simple process to obtain the sebaceous acid. Suet is melted, and quick-lime added; when the mixture is cold, it is boiled in a large quantity of water, which, by filtration and evaporation, affords the sebaceous salt of lime, of a brown colour, and acrid taste. This is purified by calcination in a crucible, solution, and filtration; a sufficient quantity of water, impregnated with cretaceous acid, being added, to separate the superabundant lime. The fluid being evaporated, affords a white salt, from which, by distillation with the vitriolic acid, the sebaceous acid is disengaged.

This acid exists in the butter of cocoa, spermaceti, and probably in vegetable oils. The following are its characters: it is li-

quid, white, and of a very strong smell; it emits white fumes, is decomposed by fire, becomes yellow, and affords cretaceous acid. It strongly reddens blue colours; unites, in all proportions, with water; forms a crystallizable salt with lime; and with pot-ash and soda, salts which crystallize in needles, and are fixed in the fire. It appears to act on quartz, and on glass, like the acid of syrup. (See § IV. of the discourse placed at the beginning of the first volume.) It dissolves gold, when united with the nitrous acid; attacks mercury and silver; precipitates the nitre and acetous salt of lead; it precipitates cream of tartar, and separates the vinegar from tartar, and from the acetous salt of pot-ash. When strongly heated on vitriolic salts, it separates the acid in the sulphureous state. It precipitates the nitre of mercury and of silver. Many of these properties induced Mr. Crell to think, that the sebaceous acid might be nothing more than a modification of the muriatic acid; but M. Morveau observes, that as it decomposes corrosive sublimate, that character alone is sufficient to distinguish them.

Acids produce a change in fat, which is similar to that produced by combustion. They likewise appear capable of converting it into an acid soap, soluble in water.

Sulphur unites very well with fat, and forms a combination, which has not yet been accurately examined.

Fat

Fat is capable of dissolving certain metals; it unites with mercury, in the well known preparation, called mercurial ointment. For this purpose, the metal is triturated with hogs lard for a long time; the mercury becomes divided, attenuated, and so intimately united with fat, that it communicates to it a slate-colour, and loses its metallic form. This union, however, appears to be nothing more than an extreme division, or at most there is only a small portion of the mercury dissolved by the acid of the fat, since globules of mercury may always be distinguished by a lens in the best prepared ointment.

Lead, copper, and iron, of all the metals are the most easily altered by fat. The calces of these metals combine very readily with this substance; and for that reason it is dangerous to leave food of a fat nature in vessels of copper, or even in those of earth, which are covered with glass of lead. In the combinations of fat with the calces of metals, it is observed, that the latter assume readily the metallic state when heated: this phenomenon arises from the inflammable gas, which is disengaged from the fat, and unites with the oxygenous principle of the calx.

Most vegetable matters are capable of uniting with fat; extracts and mucilages give it a degree of solubility in water, or at least favour its suspension in that fluid.



It combines with oils in all proportions, and communicates to them a part of its consistence.

These are the chemical properties of fat which are at present known: they teach us, that this substance greatly resembles butter; that is to say, it is a kind of fat oil, rendered concrete by a portion of acid.

With regard to its uses in the animal economy, besides that of maintaining the heat of those parts which it surrounds, and the agreeable plumpness and pliancy it produces, together with the whiteness it communicates to the skin: it likewise appears, according to Macquer, to be of use in absorbing the superabundant acids which may exist in the bodies of living creatures; it is, as it were, the reservoir of those salts. It is likewise known, that too great a quantity of acid, introduced into the body of an animal, dissolves and melts the fat, doubtless by rendering it saponaceous, and consequently more soluble. The excessive abundance, and more especially the alterations of the fat, produce dangerous disorders in the animal economy, whose symptoms and effects have not yet been well examined. Lorry has particularly attended to the nature of fat, and has discovered a striking analogy between this substance and bile. Fat is used in foods, and is nourishing for such persons as have strong digestive powers. It is used externally in medicine, as a softening

ening remedy ; and as such it enters into the composition of ointments and plasters.

The marrow, contained in long bones, exhibits the same properties as fat ; but the comparative analysis has not been yet made with sufficient accuracy to describe its characteristic properties.

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### C H A P. XIII.

#### Concerning the Bile and Biliary Calculi.

**T**HE bile, or gall, is a fluid of a green colour, more or less yellow, of an excessively bitter taste, and of a faint and nauseous smell, which is separated from the blood by a glandulous viscus, universally known by the name of the liver. It is collected in most animals, except insects and worms, in a receptacle near the liver, called the gall bladder. The human bile has not yet been much examined, on account of the difficulty of procuring a sufficient quantity : the gall of the ox has been more particularly examined by chemists.

This liquor is of a glutinous, or almost gelatinous consistence ; it pours out like syrup ; and by agitation, it lathers like soap-water.

When distilled in the water-bath, it affords a phlegm, which is neither acid nor alkali, but after a certain time putrefies. This phlegm has often exhibited to me a singular character; it emits an odoriferous smell, of considerable strength, and greatly resembling that of musk or amber. This experiment has been made in my courses of lectures before a number of spectators. It takes place, more especially when bile, slightly altered by having been kept some days, is submitted to distillation. When all the water which bile affords in the water-bath has been distilled off, the residue has the form of an extract, more or less dry, and of a deep and brownish green. This extract of bile attracts the humidity of the air, is very tenacious and pitchy, and is totally soluble in water; by destructive distillation, it affords volatile alkali, empyreumatic animal oil, much concrete volatile alkali, and an elastic fluid, consisting of a mixture of cretaceous and inflammable gas; after this operation, a coal remains of considerable bulk, and less difficult to incinerate than those we have hitherto spoken of. According to Mr. Cadet, who communicated a very valuable memoir, on the analysis of bile, to the Academy, in the year 1767, this coal contains mineral fixed alkali, a salt which he thinks to be of the same nature as sugar of milk, an animal earth, and a small portion of iron. It must

must be observed, that this distillation must be made slowly, because the matter expands considerably. Bile, exposed to a temperature between 65 and 85 degrees, quickly changes, its smell becomes more nauseous, its colour is destroyed, whitish mucilaginous flakes are precipitated, its viscosity disappears, and its smell soon becomes fetid and penetrating. When the putrefaction is in an advanced state, its smell becomes sweet, and resembles amber. My pupil, M. Vauguelin, has discovered, that bile, heated in the water-bath, and slightly evaporated, may be afterwards preserved for many months without alteration, as is likewise the case with respect to vinegar.

Bile is very soluble in water, and when thus diluted, becomes of a yellow colour, which is lighter, in proportion to the quantity of water added.

All the acids decompose it in the same manner as soap, and produce a coagulum. If this mixture be filtrated, and the fluid evaporated, a neutral salt is obtained, which is found to consist of the acid made use of and soda. This valuable experiment, first made by Mr. Cadet, proves the existence of the mineral fixed alkali in the bile. The matter remaining on the filter, in these experiments, is thick, viscid, very bitter, and very inflammable; its colour and consistence vary, according to the nature and concentration of



the acid made use of. I have observed, that the vitriolic acid gives it a deep green colour; the nitrous acid, somewhat concentrated, a brilliant yellow; and the muriatic acid, a very beautiful light green: these colours, however, vary greatly, according to the state of the bile, and of the acids. This precipitate is a true resin, which swells, melts, and takes fire on hot coals, is totally soluble in spirit of wine, and precipitable by the addition of water. The action of acids on bile, proves, therefore, that it is a true soap, formed by an oil of the nature of resins, combined with soda. They likewise indicate the presence of a certain quantity of the albuminous matter in this animal fluid, which causes it to coagulate by fire, by acids, or by putrefaction.

Neutral salts, mixed with bile, prevent its putrefaction.

Metallic solutions, and bile, mutually decompose each other; the fixed alkali of this humour unites to the acid of the solution, and the resin of the bile precipitates in combination with the metallic calx.

Bile unites readily with oils, and takes them out of cloaths in the same manner as soap.

This fluid is soluble in spirit of wine, which separates the albuminous matter. The tincture of bile is not decomposed by water; which shews, that this substance is  
a true

a true animal soap, equally soluble in aqueous and spirituous menstrea. Ether likewise dissolves it very readily.

Vinegar decomposes bile in the same manner as the mineral acids; when the filtrated liquor is evaporated, the acetous salt of soda is obtained, well crystallized.

From these several experiments, it follows, that bile is a compound of much water, a peculiar spiritus rector, albuminous mucilage, oil of the nature of resins, and cretaceous soda. Mr. Cadet found it to contain a salt, which he thinks to be of the nature of sugar of milk, and whose existence has been since confirmed by Mr. Van Bochaute.

Bile, considered with respect to the animal economy, is a fluid which appears to assist the process of digestion. Its saponaceous quality renders it capable of uniting oily substances with water. Its bitter taste proves, that it stimulates the intestines, and promotes their action on the aliments. Roux, a celebrated physician and chemist of the Faculty of Medicine at Paris, whose premature death is a heavy loss to the sciences, was of opinion, that the bile is likewise principally calculated to evacuate the colouring part of the blood from the body. It appears to be decomposed in the duodenum, by the acids which are almost always disengaged in digestion. It is certain,  
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at least, that it is greatly altered, especially in its colour, when it composes part of the excrements. Judicious physicians may therefore, in many cases, make useful inferences from the inspection of these matters, which indicate the state of the bile, and that of the liver, which separates it.

The extract of the gall of bullocks, and of many other animals, is used as a very good stomachic medicine. It supplies the defect and inactivity of the bile, restores the tone of the stomach, and establishes the functions of that organ, when debilitated; but great care must be taken in its use, because it is acrid and heating; and it must be administered only in very small doses, especially in irritable subjects.

Whenever the human bile is detained in the gall bladder by any cause, and especially by spasmodic contractions, as in melancholic or hysteric disorders, long continued grief, &c. it thickens, and produces brown, light, inflammable concretions, of a very strong bitter taste, which are called biliary calculi. These concretions are often very numerous, distending the gall bladder, and sometimes intirely filling it. They produce violent hepatic cholics, vomiting, jaundice, &c.

These calculi have been examined by M. Poulletier de la Salle. He has observed, that they are dissoluble in ardent spirit.

After

After having digested the stones in spirit of wine for a certain time, he observed, that the fluid was filled with slender, brilliant, and crystalline particles, having all the appearances of a salt, and the experiments made on this saline substance, shewed, that it resembles, in certain properties, the acid salt, known by the name of flowers of benzoin. From the experiments of this philosopher, it seems, that this salt is only contained in the biliary calculi of man, as he did not find it in those of oxen.

The discovery of M. Poulletier de la Salle, has been confirmed by facts observed at the Royal Society of Medicine, respecting the stones of the gall-bladder. This society received from several physicians, biliary calculi of a peculiar nature, which have not hitherto been described. They consist of a mass of crystalline transparent laminae, similar to mica, or talc, which have absolutely the same form as the salt discovered by M. Poulletier. It even appears, that the human bile is capable of affording a great quantity of these crystals; for the Society of Medicine is in possession of a gall-bladder intirely filled with this saline transparent concretion. It is much to be wished, that the nature of these new calculi may be examined into, as researches on this subject cannot but be very useful to medicine.

From these accounts, two kinds of biliary



liary calculi may be distinguished; the one, opaque, brittle, inflammable, and truly bilious; the others transparent, crystallized in laminæ, and appearing to be a saline principle of the bile, which, though it has not yet been proved, may perhaps exist in greater quantities, in certain morbid affections of this fluid, than in the natural state, and which in this case is disposed to be precipitated and crystallized, whenever the gall is detained in considerable quantities in its bladder.

Soap, the mixture of oil of turpentine and ether, &c. have been proposed to dissolve the biliary calculi. It is an important observation, that they are only found in the gall-bladder of oxen, after dry seasons, and a scarcity of fresh fodder; and that they disappear in the spring and summer, when these animals find abundance of green and succulent vegetables. The butchers are well acquainted with this phenomenon; they know that these stones are found in oxen from the month of November to the month of March, and not afterwards. This phenomenon sufficiently shews the power of the saponaceous juices of plants in dissolving the biliary calculi.

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C H A P. XIV.

Concerning the Saliva, the Pancreatic Juice,  
and the Gastric Juice.

**A**NATOMISTS and physiologists have observed a great analogy between the saliva and the pancreatic juice. The salivary glands, and the pancreas, have in fact a structure intirely of the same kind, and the use of the fluids, secreted by these organs, appears to be the same. Man, and quadrupeds, are the only animals in which the saliva exists; or at least the salivary glands have not been observed in any other animals.

No accurate chemical experiments have yet been made with these two fluids. This circumstance may be attributed to the difficulty of procuring either, even in very small quantities. It is only known, that the saliva is a very fluid juice, separated by the parotides, and many other glands, which continually flows into the mouth, but most abundantly during mastication. It appears to be of a saponaceous nature, impregnated with air, which renders it frothy; it leaves but a small residue, when evaporated

porated to dryness; but it forms, nevertheless, certain salivary concretions in the passages which convey it into the mouth. It appears to contain an ammoniacal salt, since lime and caustic fixed alkalis disengage from it a penetrating and urinous odour. Pringle, from experiment, concluded, that the saliva is very septic, and that it favours digestion, by exciting a commencement of putridity in the aliments. M. Spallanzani, and many other modern physicians, think, on the contrary, that it possesses the property of retarding and impeding putrefaction.

The gastric juice is separated by small glands, or the arterial extremities, which open into the internal tunic of the stomach. The oesophagus likewise affords a small quantity, especially in the inferior region. Glands of considerable magnitude are observed in many birds, which open into very sensible excretory ducts.

Modern philosophers have paid great attention to the gastric juice. Messrs. Spallanzani, Scopoli, Monch, Brugnatelli, Carminati, have, within the last few years, examined the properties of this liquor. They collected it in the stomach of sheep and calves, by opening them, after having suffered them to fast for some time. They obtained it from carnivorous and gallinaceous birds, by causing them to swallow spheres and tubes of metal, pierced with holes, and filled

filled with very fine sponge. M. Spallanzani examined the gastric juice of his own stomach, by procuring a vomit, or by swallowing wooden tubes, filled with different substances, to judge of the effect of the gastric juice on each of them. The experiments with tubes had been before attempted by M. De Reaumur. Lastly, M. Gossé of Geneva had the courage to cause himself to vomit a great number of times, by a process which is peculiar to himself, and consists in swallowing the air. From all the modern observations, the gastric juice appears to possess the following properties.

It is the principal agent of digestion, and changes the aliments into a kind of uniform soft paste: it acts on the stomach itself after the death of animals. Its effects shew, that it is a solvent, but of that peculiar nature, that it dissolves animal and vegetable substances uniformly, and without exhibiting a stronger affinity for the one than for the other. Far from being of the nature of a ferment, it is one of the most powerful antiseptics we are acquainted with: and from the experiments of the philosophers before cited, its nature appears to be essentially different in the several classes of animals. According to M. Brugnatelli, the gastric juice of birds of prey, and granivorous birds, is very bitter, and composed of a disengaged acid, resin, animal matter, and common salt; that of ruminating



ruminating quadrupeds is very aqueous, turbid, and salt, containing volatile alkali, an animal extract, and common salt. M. de Morveau, having digested portions of the internal tunic of the stomach in water, found that it has an acid character. M. Spallanzani thinks, that this character depends on the aliments, as he never found the acid juice in the stomach of carnivorous animals, but always in those which feed on grain. M. Goffe made the same observation on himself, after having used crude vegetables for a long time. It therefore appears, according to the opinion of M. Spallanzani, that the gastric juice, in its natural state, is neither acid nor alkaline, or that, if it contains a peculiar acid, it is in the neutral state. M. Brugnatelli thinks, that the white matter, in the excrements of carnivorous birds, contains phosphoric acid; but M. de Morveau observes, that his experiments are not conclusive. M. Scopoli found sal-ammoniac, and suspects that the muriatic acid is produced by the vital power of animals; but no decisive fact has been brought in support of this opinion; every circumstance, on the contrary, tending to shew, that this acid comes from the food.

Hence it may be concluded, 1. That the gastric juice is not yet well known; 2. That it appears to be different in the several classes of animals, and in the same animal, according

ing to the diversity of food; 3. That no proof has been brought to shew that it is a peculiar acid; 4. That its most remarkable property consists in its great solvent power, which extends even to bony and metallic substances; an indifference, or want of preference between the matter it acts on, and especially a very strong antiseptic quality, which it communicates to all the bodies it is mixed with, and which even puts a stop to putrefaction, in substances which have already begun to be changed by that process.

This last property has excited a greater degree of attention than the others. Messrs. Carmanati, Jurine, and Toggia, have applied the gastric juice on wounds. M. Carmanati has even used it internally; and they all agree, with respect to its antiseptic virtue. Time and experience must decide on the efficacy of this new remedy.

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C H A P. XV.

Concerning the Humours, or Animal Matters, which have not yet been examined; such as Sweat, the Nasal Mucus, the Cerumen, Tears, the Gum of the Eyes, the Seminal Fluid, and the Excrements.

**T**HERE are many animal fluids and matters, which have not yet been examined. It is therefore not so much with a view to exhibit their properties, as to engage young physicians to make researches, equally new and useful, that we propose to speak cursorily respecting the humour of transpiration, of sweat, of the mucus of the nostrils, the cerumen of the ears, the tears, the gummy matter of the eyes, the seminal fluid, and the excrements.

Physicians have discovered a great analogy between the fluid emitted by cutaneous transpiration and urine; they have observed, that these excretions mutually answer the same purpose in many circumstances, and are therefore naturally led to consider the vaporous fluid of transpiration, as of the same nature as urine. Medical practice has shewn,  
that

that its qualities are subject to variation; that its smell is faint, aromatic, alkaline, or sour; that its consistence is sometimes glutinous, thick, tenacious, and that it leaves a residue on the skin; that it often tinges linen with various shades of yellow. M. Berthollet affirms, that sweat reddens blue paper, and that this phenomenon takes place more particularly in parts affected with the gout. He thinks it contains the phosphoric acid. It has been hitherto impossible to collect a sufficiently large quantity of this excremental humour, to examine its properties with accuracy. Many inquiries, therefore, remain to be made, which can only be undertaken and pursued by physicians in peculiar circumstances and occasions.

The humour, prepared by the membrane of Schneider, which is thrown out of the nostrils by sneezing, deserves to be carefully attended to by physicians. It is a kind of thick mucilage, white, or coloured, more or less fluid or consistent in certain affections, and more especially in catarrhs. No one has yet examined it.

The yellow, greenish, or brown matter, which is collected, and becomes thick, in the auditory canal, and is known by the name of wax, because of its consistence, has not been examined. It is very bitter, and appears to be of a resinous nature; it sometimes becomes so concrete, as to stop the



auditory canal, and prevent the free passage of sound: there seems to be some analogy between this and the inflammable matter of the bile.

No one has yet made experiments to discover the nature of tears, which are prepared in a peculiar gland, situated towards the external angle of the orbit, and destined by nature to maintain the humidity and suppleness of the external parts of the eye. This fluid is clear, limpid, and manifestly salt; it sometimes issues out of the eye in large quantities. In the natural state, it gradually flows into the nostrils, and appears to dilute the mucus. Most authors who have spoken of this liquor, and in particular Pierre Petit, a physician of Paris, who published a treatise on Tears about the end of the last century, consider them as water nearly pure. The gum, or humour, which adheres to the borders of the eye-lids, and appears to be separated by the glands of Meibomius, is not better known than the tears.

Neither has the chemical nature of the seminal humour been more inquired into than that of the foregoing matters. The few observations, which it has been hitherto possible to make on this humour, have shewn, that it resembles animal mucilages, becomes fluid by cold and by heat, and that the action of fire reduces it to a dry and friable substance.

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The anatomical and microscopical observations on this subject have been carried much further. They have shewn, that the seminal humour is an ocean, in which certain small round bodies swim, which possess a rapid motion, and are by some considered as living animals, destined to reproduce the species, and by others as organic molecules, adapted to form a living being by their union. The microscope, in the hands of a modern observer, has likewise shewn crystals formed in the seminal liquor by evaporation and cooling. It must be admitted, however, that these fine experiments have not hitherto been attended with consequences which have advanced the sciences, but that they have merely afforded data for the construction of certain ingenious hypotheses.

The food, by which animals are supported, contain a large quantity of matter, which is not capable of nourishing them, and is rejected out of the intestines in a solid form. The excrements are coloured by a portion of bile, which they carry with them. The fetid odour they exhale, arises from the commencement of putrefaction in their passage through the intestines. Homberg is the only chemist who has examined these matters. He observed, that the phlegm afforded by excrements distilled on the water-bath, was of a nauseous smell; by washing and evaporation, he obtained a salt,

which melted like nitre, and took fire in close vessels. The distillation of this matter in a retort, afforded the same products as other animal substances. Putrefied excrements afforded an oil without colour or smell, which did not convert mercury into silver, as he had been led to expect.

It must be observed, that the fecal matter examined by Homberg, was that of men, fed with coarse bread, and champaign wine; a circumstance which was said to be essential, in order to succeed in the alchemical experiments he was directed to make. There can be no doubt, but that the properties of the excrements must depend on the nature of the food, of which they are merely the residue.

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### C H A P. XVI.

#### Concerning Urihe.

**U**RINE is a transparent excrementitious fluid, of a citron yellow, a peculiar smell, and a saline taste, separated from the blood by two glandular organs, called kidneys, and from thence conveyed into a reservoir, which is universally known by the name of the bladder, and in which it remains

mains for a certain time. This fluid is a kind of lixivium, containing the acrid matters of the animal humours, which, if retained too long in the body, might be productive of mischief and inconvenience. It is a solution of a great number of salts, and two peculiar extractive substances; and its quantity and quality varies according to circumstances. The urine of man, which we propose to examine in particular, differs from that of quadrupeds; and the differences are still more considerable between the other classes of animals. The state of the stomach, and that of the fluids in particular, produce a great number of alterations, which cannot be ascertained but by a long continued series of experiments, few of which have yet been made. We shall therefore only speak, in this place, of the urine of the human species in a healthy state.

This fluid is distinguished by physicians into two kinds; the one, called crude urine, when emitted a short time after meals, is clear, and almost destitute of taste and smell; it contains a much smaller proportion of the principles than the other, which is called urine of the blood, or urine of concoction.

This last is not emitted till the process of digestion is finished, and it is separated from the blood by the kidneys; while the former appears to be filtrated, in part, from the stomach and intestines immediately to the bladder,



bladder, by means of the cellular membrane,

The state of health, and especially the disposition of the nerves, have singular effects on the urine. After hysteric or hypochondriac attacks, it flows in large quantities, and is without smell, taste, or colour. The disorders of the bones, and of the articulations, have likewise a great influence on this animal lixivium. It often deposits a great quantity of matter, apparently earthy, but which seems to be a calcareous phosphoric salt, as we shall hereafter observe. The urine of those who have the gout is of this kind. Physicians, particularly Herissant and Morand, have observed, that when the bones are affected, or become soft, the urine deposits a large quantity of this matter. It is likewise observed, that in the healthy state, the urine contains a quantity of this matter, which is the basis of bones, and was probably more than was required for the nutrition and reparation of those organs.

Many foods are capable of communicating certain peculiar properties to urine. Turpentine produces a smell of violets, and asparagus a very fetid smell, in this fluid. Such persons as have weak stomachs, void urine, which retains the smell of such foods as they have taken. Bread, garlick, onions, soup, and all vegetables, communicate their own proper smell to the urine.

From

From these facts, it follows that the urine exhibits phenomena, from which the physician may derive the greatest practical advantages. But it must not be concluded, that a simple inspection of the urine is sufficient to determine the nature of a disorder, the sex of the patient, and the remedies which are proper to be applied, as certain empirics pretend.

The human urine, considered with respect to its chemical properties, is a solution of a considerable number of different substances. Some of these are salts, similar to those of minerals, and, as Macquer thinks, are derived from the foods, without having suffered any alteration. Others are found to be analogous to the extractive principle of vegetables; and lastly, there are others which appear to be peculiar to animals, and even to urine, or which have not at least been found in considerable quantities in the products of the other kingdoms, nor even in other animal substances, except urine. After having shewn the method of extracting these several matters from urine, we shall proceed to the history of such as are peculiar to this fluid, and have not yet been described.

Urine was formerly considered as an alkaline liquor, or *lixivium*; but M. Berthollet has remarked, that it always contains an excess of phosphoric acid, and reddens the tincture of turnsole. This physician has  
observed,

observed, that the urine of gouty persons contains less acid salt than that of persons in perfect health; that during the fit of the gout, this fluid is much more acid than usual, though not more so than the urine of a robust person. He conjectures, that in gouty patients the phosphoric acid is not evacuated by urine, as in healthy persons; that it wanders, as it were, and is carried into the articulations, where it excites irritation and pain. This excess of acid in the urine holds the calcareous phosphat in solution.

M. Scheele seems to think, that this disengaged acid of urine is not merely phosphoric acid, but consists of partly the same acid as he has discovered in the human calculus, and is called the lithiastic acid by M. de Morveau. The latter acid, which is capable of concretion and crystallization, forms, according to the Swedish chemist, the red crystals which are deposited from urine, and also the brick-coloured precipitate, observed in the urine of such as have fevers. The tophaceous concretions, in the articulations of gouty persons, are likewise of the same nature as the calculus; that is to say, for the most part formed of the lithiastic acid; hence we see, that M. Scheele does not agree in opinion with M. Berthollet. I shall give my thoughts on the subject in the history of the calculus of the bladder.

Fresh

Fresh urine, distilled in the water-bath, affords a large quantity of phlegm, which is neither acid nor alkaline, but quickly putrefies. As this phlegm contains nothing of value, the urine is commonly evaporated on a naked fire. In proportion as the water, which forms more than seven-eighths of this animal humour, is dissipated, the urine becomes of a brown colour; a pulverulent matter is separated, of an earthy appearance, which has been taken for selenite, but is a true salt of difficult solubility, and is composed of the phosphoric acid and lime, with a small excess of acid. This salt is of the same nature as the basis of bones, and is mixed with a small quantity of concrete lithiasic acid. When the urine has obtained the consistence of a clear syrup, it is filtrated, and set in a cool place; at the end of a certain time, saline crystals are deposited, which consist of marine salt, and two peculiar saline substances. These salts are known by the names of fusible salt, or native salt of urine: we shall examine their properties in the following chapter. Several successive products of these crystals are obtained, by repeated evaporations, at the same time that a certain quantity of marine and febrifuge salt crystallizes. When the urine affords no more saline matter, it is in the state of a very thick brown fluid, which is a kind of mother water, and holds in solution



solution two peculiar extractive substances. By evaporating it to the consistence of a soft extract, and treating the residue with spirit of wine, Rouelle the younger has discovered, that a portion is dissolved, and the other part remains untouched. He calls the first saponaceous matter, and the second extractive matter.

The saponaceous substance is saline, and capable of crystallization. It is not dried without difficulty; and in this state it attracts the moisture of the air. By destructive distillation, it affords half its weight of ammoniacal chalk, a small quantity of oil, and ammoniacal muriate. Its residue converts the syrup of violets to a green.

The extractive substance, soluble in water, and not in spirit of wine, is easily dried in the water-bath, like the extracts of plants; it is black, less deliquescent than the former, and affords, by distillation, all the products of animal matters. Such, according to Rouelle, are the characteristic properties which distinguish these two component parts of the extract of urine. We may likewise add, that this celebrated chemist obtained from one ounce to an ounce and a half of extract from a pint of urine, voided after concoction; whereas the same quantity of crude urine afforded no more than one, two, or three drachms.

If the extract of urine, instead of being  
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separated by spirit of wine, be distilled intire, it affords much ammoniacal chalk, a very fetid animal oil, ammoniacal muriate, and a small quantity of phosphorus: its coal contains a small proportion of muriate of soda, or common salt. This analysis of urine shews, therefore, that it is composed of a large quantity of water, the disengaged phosphoric and lithiasic acids, muriate of soda, combinations of the phosphoric acid with calcareous earth, mineral alkali, and volatile alkali, together with two peculiar extractive matters, which give the fluid its colour. As to the deep colour it acquires in many disorders, and especially in all bilious affections, I have discovered, that it is produced by the resin of the bile, and that its extract, dissolved by spirit of wine, is precipitated by water.

Urine when exposed to the air, changes more quickly in proportion as the atmosphere is hotter. Depositions are first formed by simple cooling; several saline matters crystallize at its surface and bottom, and frequently a reddish salt, which appears to be of the nature of the calculus. No one has observed the spontaneous changes of this excrementitious fluid but Mr. Halle, my associate. He has distinguished, in the decomposition of urine left to itself, several terms, or periods, which afford sediment, or crystals, of different natures, and are attended

tended with various changes. Our present purpose not extending to the detail of all these changes, which are accurately described in an excellent Memoir, inserted among those of the Royal Society of Medicine for the year 1779, we shall confine ourselves to the principal alterations to which it is subject. Soon after it has become cold, its smell changes, becomes stronger, and indicates the presence of volatile alkali; its colouring matter changes, and is separated from the rest of the liquor; lastly, this alkaline smell is dissipated, and is followed by another, less penetrating, but more disagreeable and nauseous; and the decomposition proceeds to its complete termination. Rouelle the younger has observed, that crude and serous urine does not putrefy so quickly; that its smell, after it has become changed, differs greatly from that of the urine of concoction; and lastly, that it becomes covered with mouldiness, like the juices of vegetables, and solutions of animal jelly. Mr. Halle has observed certain urines which became very acid before they passed to the state of putrefaction. Urine, putrefied for a year, or more, affords fusible salt, as well as fresh urine; but it affords a much larger quantity of disengaged phosphoric acid, and effervesces with cretaceous volatile alkali. The putrefaction extricates and drives off a part of the volatile alkali. The salt deposited

fited on the sides of the vessel during evaporation, is strongly acid; and the quantity may be increased, by adding volatile alkali, according to the advice of Rouelle the younger.

Quick-lime, and dry fixed alkalis, immediately decompose the principles contained in urine. Nothing more is required, than to pour a solution of caustic, vegetable, or mineral alkali, into fresh urine, in order to produce an insupportable putrid alkaline smell. This is produced by the decomposition of the ammoniacal phosphat. M. Berthollet has discovered, that lime-water, added to fresh urine, produces a precipitate, from which phosphorus may be obtained. This phenomenon depends on the union of the lime with the excess of phosphoric acid; and the precipitate consists of, 1. The calcareous phosphat, naturally contained in urine, and which was suspended merely by the excess of phosphoric acid; 2. An additional portion of calcareous phosphat, formed by the union of the superadded lime with the disengaged acid. M. Berthollet, having observed that caustic volatile alkali likewise precipitates the calcareous phosphat of urine, by neutralizing the disengaged phosphoric acid which held that salt in solution, remarks, that the weight of this precipitate, compared with that produced by lime-water, indicates the quantity of disengaged



engaged phosphoric acid contained in the urine; because, in fact, the ammoniacal phosphat, formed in this experiment, remains dissolved; whereas the calcareous phosphat produced by lime-water, being insoluble, is precipitated at the same time as the other portion of calcareous phosphat, which naturally exists in the urine.

Acids have no action on fresh urine, but they quickly take away the smell of putrefied urine, and of the depositions it forms in that state.

Urine decomposes many metallic solutions. Lemery distinguished by the name of the rose-coloured precipitate, a magma of that colour, which is formed when the nitrous solution of mercury is poured into urine. This precipitate is partly formed by the muriatic acid, and partly by the phosphoric acid contained in this fluid. M. Brongniart has observed, that this preparation sometimes takes fire by friction, and burns rapidly on hot coals; he attributes this effect to a small portion of phosphorus.

Such is the present state of our knowledge respecting the chemical properties of urine. Much remains to be done, before we may esteem ourselves in possession of all that analysis is capable of discovering with regard to this fluid. It is necessary, for this purpose, to examine the different depositions  
observed

observed in urine, and well described by Mr. Halle, the red or transparent saline concretions which are formed, and which Mr. Scheele takes to be the lithiatic acid; the abundant sediment which urine affords after fits of the gout, in such as are attacked by the stone, &c.

We shall now proceed to examine the peculiar saline products, obtained from urine, to whose properties it is very necessary to attend.

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## C H A P. XVII.

Concerning the Ammoniacal Phosphat, the Phosphat of Soda, and the Calculus in the Bladder.

WE have seen that urine contains many peculiar salts; these salts are combinations of the phosphoric acid with volatile alkali, soda, and lime, and the base of the calculus of the bladder. We shall successively examine these substances under the denominations given them by M. de Morveau, of ammoniacal phosphat, phosphat of soda, and lithiatic acid. We shall describe the properties of the calcareous phosphat when we treat of bones.

The salt, obtained by the cooling of evaporated

porated urine, has been called fusible salt in general, because it melts in the fire, as we shall presently see; it has likewise been called essential salt of urine, or microcosmic salt: in this first state, it is far from being pure, but is contaminated by an extractive substance, together with marine salt and phosphat of soda. Several chemists, Margraaf in particular, supposed that it was necessary, in order to avoid the mixture of marine salt, that the urine should putrefy; they imagined, that the marine salt became converted into fusible salt by the putrid action; a fact which is now known to be false. One hundred and twenty pounds of recent urine, afford, according to Margraaf, about four ounces of this salt, and two ounces of phosphat of soda.

The accurate separation of these two saline substances, which Shockwitz, le Mort, Borerhaave, Henkel, and Schlosser, considered as one and the same salt, is not easy. To effect this, the usual advice is to dissolve the fusible salt in hot water, evaporate the fluid, and crystallize it. But Rouelle the younger, and the Duc de Chaulnes, are the only chemists who have mentioned a very great and singular difficulty presented in this process. The greatest part of the fusible salt is dissipated by the heat when the solution is evaporated; three-fourths being lost by this means. The Duc de Chaulnes has described a process

cess for purifying it with the least possible loss: it consists in dissolving, filtering, and cooling this solution in well closed vessels; in either case, a salt, crystallized in very flat, rhomboidal four-sided prisms, is obtained, which is the ammoniacal phosphat; and above these first crystals, another salt, in cubes, or rather in long, square tablets, very different from the other, and which is the phosphat of soda: this last may be separated, according to the remark of Rouelle the younger, by removing its efflorescence from the former, which does not change.

Ammoniacal phosphat, thus purified, and separated from the phosphat of soda, has the form of very flat, rhomboidal tetrahedral prisms, as we have observed, which are often truncated lengthwise on their acute edges, by which they become converted into a kind of hexagonal prisms; there are likewise found, according to Romé de Lisse, from whom the present description of this salt is taken, longitudinal segments of these prisms, whose longest face resting on the vessel, has a rhomboidal form, and is intersected by two diagonal lines. The tetrahedral, and octahedral forms, attributed to this salt, are not met with, excepting when it contains marine salt and phosphat of soda; the muriate of soda appears more particularly to possess the property of modifying the form into that of an octahedron, since marine salt, dissolved



in urine, and exposed to the sun, affords regular octahedrons at the end of some days. The taste of this salt is at first cool, afterwards urinous, bitter, and penetrating; when placed on a burning coal, it swells, emits a smell of volatile alkali, and melts into a deliquescent globule, when urged by the blow-pipe. If distilled in a retort, very penetrating and caustic volatile alkali is disengaged; the residue is a transparent glass, very fixed, and very fusible, which attacks the glass of the retorts. Margraaf affirms, that it is soluble in two or three parts of distilled water, and presents the characters of an acid. M. Rouelle affirms, that it is deliquescent. M. de Morveau, on the contrary, thinks that by means of heat it may be brought into the state of a permanent glass. M. Proust has discovered, that this vitreous residue is a combination of the phosphoric acid with a portion of a peculiar matter, which he did not appear to be acquainted with; but which, from the inquiries of several modern chemists, has been found to be phosphat of soda. It must however be observed, that this compound glass is not obtained, excepting when ammoniacal phosphat, which still retains a portion of the phosphat of soda, is distilled, and that in this case the glass appears to be always either opaque, or very capable of becoming

coming so, while very pure ammoniacal phosphat leaves a transparent glass.

The ammoniacal phosphat is not changed by exposure to air.

It is very soluble in water, no more than five or six parts of cold water being required to hold it in solution. Hot water, at the temperature of 170 degrees, decomposes it, and even volatilizes a portion of its acid.

The ammoniacal phosphat causes siliceous earth, clay, ponderous earth, magnesia, and lime, to enter into fusion; but these vitreous compounds are effected by the phosphoric acid, the volatile alkali itself being driven off.

Quick-lime, and the two pure fixed alkalis, decompose ammoniacal phosphat, and separate the volatile alkali: if lime-water be poured into a solution of this salt, a white precipitate is obtained, which consists of calcareous phosphat. The alkalis and all the cretaceous neutral salts decompose it likewise, and separate the volatile alkali in the form of ammoniacal chalk.

The action of the mineral and the vegetable acids on ammoniacal phosphat has not yet been sufficiently examined. This action is referable to the various elective attractions which exist between the phosphoric acid and its alkaline base: we shall treat of them when we come to speak of that acid.

We shall likewise refer the alterations ammoniacal salt is susceptible of, from metals and their calces, to the same part of our work, because those alterations absolutely depend on the phosphoric acid.

Ammoniacal phosphat, treated with charcoal in close vessels, affords phosphorus. Bergman has proposed it as a flux in assays with the blow-pipe.

We have already described the method of obtaining the phosphat of soda by itself; it will be proper, in this place, to mention the several dates of this discovery.

Hellot appears to be the first who spoke of it, in the year 1737, but he took it for selenite. Haupt mentioned it in 1740, under the name of *sal mirabile perlatum*. Margraaf described it in the year 1745. Pott spoke of it in 1757; and, like Hellot, took it for selenite. Rouelle the younger examined it particularly in the year 1776, and called it fusible salt, with base of natrum. All these chemists perceived the difference between this salt and the foregoing, to consist more especially in its not affording phosphorus with charcoal; but Rouelle ascertained its properties better than any other chemist; according to him, its crystals are flat, irregular, tetrahedral prisms, one of whose extremities is dihedral, and composed of two rhomboids, the other end adhered to the base. The four sides of the solid, are  
two

two alternate irregular pentagons, or two long rhombuses.

The phosphat of soda, or fusible salt, with base of natrum, exposed to the fire in a crucible, melts, and affords a white opake mass; when heated in a retort, it gives out phlegm, without any character either of acid or alkali; its residue is a glass, or opake frit.

This salt effloresces, and falls intirely into powder, by exposure to air.

It readily dissolves in distilled water, and crystallizes by evaporation; its solution converts the syrup of violets to a green.

Calcareous nitre decomposes it, and affords a precipitate of calcareous phosphat: the supernatant liquor affords a nitre of soda.

This salt is likewise decomposed by the nitrous solution of mercury. It affords a white precipitate, which, distilled in a retort, produces a small quantity of reddish sublimate, with running mercury, and leaves at the bottom of the vessel a white opake mass, adhering to and combined with the glass. This mercurial precipitate, boiled with a solution of the salt of soda, forms again the fusible salt with base of natrum, and leaves the mercury in the state of a brick-dust powder. All these facts were discovered by Rouelle the younger. M. Proust, at the instance of this celebrated chemist, whose pupil he was, made a considerable number of experiments, the principal results of which are the following.



The residue of phosphorus, made with fusible salt of the first crystallization, from which no more than one-eighth of salt of phosphorus had been obtained, was lixiviated, and, by evaporation in the open air, afforded quadrangular crystals, of an inch in length, whose quantity, according to him, amounted to five or six drachms in the ounce of fusible salt employed in making the phosphorus. We must observe, that the quantity must be diminished, on account of the water which enters into the crystals. This saline substance melts by fire into an opaque glass; colours flame green; effloresces in the air; decomposes nitrous and marine salts, by disengaging their acids; forms glasses with earthy matters in a melting heat, and saturates alkalis like an acid. From this examination, M. Proust thinks it different from all the saline substances known, that it was united with the phosphoric acid and volatile alkali in the ammoniacal phosphat, and that it formed with soda the fusible salt with base of natrum, of Rouelle. He observed, that it acted as an acid, and compared it to sedative salt; and with this idea M. Proust made new experiments on the fusible salt of base of natrum, obtained by the process of Rouelle before described.

According to him, lime decomposes this salt, and has a stronger affinity with the opaque substance, which serves the purpose  
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of an acid, than with soda. If lime-water be poured into a solution of this salt, a precipitate is afforded, and the mineral alkali remains pure and caustic in the solution.

The mineral acids, and even distilled vinegar, decompose it by a contrary operation. Rouelle supposed that the vitriolic and nitrous acids did not act on this salt, because they occasion no apparent change; but M. Proust having mixed the vitriolic, nitrous, muriatic, and acetous acids, each separately, with a solution of fusible salt, with base of natrum, observed, that though no precipitate was afforded in these mixtures, the liquors by evaporation and cooling afforded vitriol and nitre of soda, marine salt, and the acetous salt of soda, which proves, 1. That this salt was decomposed by the acids. 2. That it contains soda, as Rouelle the younger had shewn. As to the separate substance which was before united to the mineral alkali, it is evident that it remains in solution in the fluids, at the same time with the newly formed neutral salts. M. Proust has observed, that after the mixture of vinegar, and the crystallization of the acetous salt of soda, if eight or ten times its weight of hot spirit of wine be poured into the mother water, the last portions of the neutral acetous salt were dissolved, and a magma was formed, which he washed with new spirit of wine, and afterwards dissolved

solved in distilled water. This solution of magma evaporated in the open air afforded crystals in quadrangular prisms, absolutely similar to those obtained from washing the residue of phosphorus made with the fusible salt obtained in the first crystallization of urine. This peculiar substance therefore, which resembles sedative salt, according to M. Proust, saturates the soda in the fusible salt with base of natrum. This discovery seems, in fact, to explain why it does not afford phosphorus. To these details, M. Proust added, that this new substance always existing in the true fusible salt, or ammoniacal phosphat, communicated to the phosphoric acid the property of melting into glass; for which reason I called it by the name of base of phosphoric glass, in the first edition of this work; but M. de Morveau has since ascertained, that the pure phosphoric acid obtained by phosphorus falling into deliquescence, and consequently not containing this substance, melts alone by heat into a solid and permanent glass. The series of experiments which M. Proust made with great care, and which is highly interesting in its results, induced Bergman to consider this substance as a peculiar acid, and he accordingly has given an account of it in the second edition of his Dissertation on the Elective Attractions, by the name of acid of sal perlatum, acidum perlatum, doubtless from  
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the denomination given by Haupt in the year 1740, to the fusible salt with base of natrum. M. de Morveau has since made it a particular article in his Dictionary of Chemistry, under the name of the ouretic acid, derived from the greek name of urine which affords it. But since the time of the experiments of M. Proust, the Dissertation of Bergman, and the writing of the article by M. de Morveau, M. Klaproth has published in Crell's Chemical Journal, an analysis of the fusible salt, with base of natrum, which destroys the existence of this pretended peculiar acid; and shews, that it is merely phosphoric acid combined with soda. M. Klaproth ascertained this fact by an experiment similar to that of Rouelle the younger; he precipitated the fusible salt with base of natrum, by calcareous, marine, or nitrous salt, the precipitate which Rouelle had before described as similar to the base of bones was found to afford phosphoric acid, by means of the vitriolic acid. M. Klaproth adds, that by saturating the phosphoric acid, obtained by the slow combustion of phosphorus with soda, even to a small excess, a salt absolutely similar to the sal perlatum of Haupt, or to the fusible salt with base of natrum of Rouelle, is obtained; and that in order to produce the substance described by M. Proust, nothing more is necessary than to deprive this salt of the excess of soda



soda by vinegar, or to add a small quantity of phosphoric acid. It is not therefore to be wondered at, after this discovery, that Bergman found absolutely the same elective attractions in the perlate acid, and the phosphoric acid. These facts have been stated by M. de Morveau in a supplement to the mineral acids; and he observes, that after this discovery, no further question will be made concerning either the ouretic acid or its salts.

It is very singular that the phosphat of soda, or sal perlatum, which after what has been said, may properly be distinguished by the former name, is not decomposed by charcoal like the ammoniacal phosphat, though this combustible substance deprives the phosphoric acid of the base of vital air, or the oxygenous principle. The soda deprives this last acid of the property of being decomposed by charcoal, though it does not act in the same manner on the vitriolic, or other acids. This is a strong exception to the elective attractions of the oxygenous principle, and stands alone; it is equally remarkable, that the acid of phosphorus added in excess to the phosphat of soda, leaves this compound, which constitutes, according to M. Klaproth, the peculiar substance of M. Proust, the property of converting syrup of violets to a green. M. de Morveau adds to the history of phosphat of soda, that when a solution of the muriate of lead is poured into a solution of this salt, a precipitate

pitate of phosphat of lead is afforded, which when distilled with charcoal affords phosphorus, as M. Laumont, inspector of the mines has discovered, with one of the ores of Huelgoet. Hence we may perceive, how the plumbum corneum proposed by Margraaf in the distillation of phosphorus of urine may augment the quantity of the product, as we shall explain in the following chapter.

The calculus or stone which is formed in the human bladder, has long engaged the attention of physicians and chemists. Paracelsus, who gave it the barbarous name of *duelech*, supposed it to be formed by an animal resin, and compared it to arthritic concretions. Van Helmont considered it as a concretion made by the salts of urine, and an earthy volatile spirit; and supposed that it differed from the arthritic salt, which was caused, according to him, by the thickening and acidification of the nutritive fluid. Boyle extracted from it oil, and much volatile salt. Boerhaave admits it to contain an earth united to volatile alkali. Hales obtained 645 times its volume of air, and out of 230 grains, the residue was only 49; he called it animal tartar. Many learned physicians, and especially Whytt and Deffen, have considered alkaline matters as the true solvent of the urinary calculus: many have even proposed soap lees, but their conclusions were not founded

founded on an accurate analysis of the calculus. Messrs. Scheele and Bergman began this analysis; they first discovered, that the stone in the bladder is formed for the most part of a peculiar acid, which M. de Morveau calls the lithiasic acid: 70 grains of calculus affords by distillation 28 grains of this acid dry and sublimed, some volatile alkali, and 12 grains of charcoal, very difficult to incinerate; 1000 grains of boiling water dissolved 296 grains of the same acid. This solution reddened blue colours, but the greater part of the acid separated by cooling in the form of small crystals.

The concentrated vitriolic acid dissolves the calculus by the assistance of heat, and becomes converted into sulphureous acid. The muriatic acid does not attack it, the nitrous acid dissolves it completely, nitrous gas and cretaceous acid being disengaged during its action; this solution is red, and contains an acid at liberty; it dyes the skin, and other animal coverings of a red; no appearance of vitriolic acid is observed by the test of soluble ponderous salts, nor of lime by the saccharine acid. Lime-water forms a precipitate, soluble in acids without effervescence; caustic alkalis dissolve the calculus, according to M. Scheele. These solutions are precipitated by lime; 1000 grains of lime-water dissolve 537, and the volatile alkali in great quantity likewise attacks the calculus. The same chemist affirms, that  
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the brick-dust coloured deposition of the urine of such as labour under fevers, is of the same nature. Though M. Scheele did not find lime in the stone of the bladder, Bergman obtained it by precipitating its nitrous solution by the vitriolic acid, and by calcining the residue of the same nitrous solution. Bergman has besides discovered in the calculus, a white spongy matter, insoluble in water, acids, and alkalis; the incinerated charcoal of this substance, whose quantity was too small to permit him to ascertain its nature, is not even soluble in the nitrous acid.

From the analysis of these two celebrated chemists, which has been often repeated with the same results in the laboratory at Dijon, the calculus appears to be of the same nature as the earth of bones; yet Mr. Tennant, of the Royal Society of London, observed stones of the bladder which only lost two-thirds by calcination, and whose residue melted into a glass, which became opaque by cooling, and consequently contained a very considerable quantity of calcareous phosphat.

As to the lithiastic acid, its properties, as far as they are at present known, 1. A concrete and crystalline form: 2. Difficult solubility in water; and in much larger quantity in hot than in cold water: 3. It changes the nature of the nitrous acid, part of whose  
oxyginous



oxyginous principle it absorbs, and then forms a reddish deliquescent mass, colouring many bodies: 4. It unites with earths and metallic calces, forming peculiar salts, which M. de Morveau calls lithiasites of lime, of pot-ash, of soda, of copper, &c.: 5. It prefers alkalis to earths: 6. It yields these bases to the most feeble acids, even to that of chalk, which is the cause of the insolubility of the calculus in cretaceous alkalis. This last character is peculiar to the present acid; however there remains, as M. de Morveau well observes, much to be done, respecting the lithiasic acid; to which I may add, that it remains to be ascertained whether it be not the modification of some other acid, as may be suspected from the known resemblance between the saccharine and oxaline acids, as well as between the pretended perlate or ouretic, and the phosphoric acid.

M. de Morveau thinks, that the arthritic concretions, which physicians have supposed to be of the same nature as the calculus of the bladder, are very different from that substance; but he grounds his opinion only on certain experiments of Schenckius, Pinnelli, and Whytt, which are far from possessing the accuracy at present required in experimental philosophy; and the observations of Boerhaave, Frederick Hoffman, Springfield, Alston, Leger, &c. on the good effects

effects of alkaline waters, soap, and lime-waters, on the arthritic and calculous affections, appear to me more proper to ascertain the existence of an analogy between these two kinds of concretions, than the former are capable of disproving it. It must however, be allowed, as M. de Morveau observes, that experiment alone is sufficient to decide the question, which affords an additional proof of the great importance of chemical researches in the art of medicine, and the advantages it promises to that useful science.

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### C H A P. XVIII.

#### Of the Phosphorus of Kunckel.

**P**HOSPHORUS is one of the most combustible substances we are acquainted with. As it was originally obtained from urine, and the substance which affords it in the greatest quantity, is the ammoniacal phosphat, whose properties we have just examined, we think it proper to treat of the history of this substance in this place.

According to Leibnitz, the discovery of phosphorus is due to an alchemist named Brandt, a citizen of Hamburg, who discovered it in 1667. Kunckel associated with

a certain person named Krafft, to purchase this secret ; but the latter having purchased it, and refusing to communicate it to Kunkel, he resolved to make a series of experiments on urine, from which he knew it was extracted, in order to discover it. His inquiries were attended with success, and therefore he ought to be regarded as the true inventor. Some persons likewise attribute the honour of this discovery to Boyle, who in fact deposited a small quantity, in the year 1680, in the hands of the secretary of the Royal Society of London ; but Stahl affirms that Krafft told him that he communicated the process of making phosphorus to Boyle : Boyle communicated his process to a German, named Godfreid Hanckwitz, who had a good laboratory at London, and was for a long time the only person who made phosphorus, and sold it to all the philosophers throughout Europe. Notwithstanding a great number of receipts for making phosphorus, and among others those of Boyle, Krafft, Brandt, Hoffman, Teichmeyer, Frederic Hoffman, Neiwentyt, and Wadelius, have been published, since the year 1680, to the commencement of the present century, no chemist succeeded in preparing it ; and the process was in reality a secret, till a stranger, in the year 1737, offered at Paris to communicate a successful method of making phosphorus. The Academy nominated four chemists,

chemists, Hellot, Dufay, Geoffroy, and Duhamel, to attend this operation in the laboratory of the Royal Garden. The process succeeded very well, the minister rewarded the foreigner, and M. Hellot described it very accurately, in a memoir inserted among those of the Academy for the year 1737. The operation consists in evaporating five or six hogshheads of urine, till it is reduced into a granulated, hard, black, and shining substance; this residue is calcined in an iron pot, whose bottom is heated red-hot, till no more fumes arise, and a smell like that of peach blossoms is perceived; the calcined matter is lixiviated with about twice its weight of hot water, and is dried after the water has been decanted off. Three pounds of this matter are then mixed with one pound and a half of coarse sand, or pounded stone-ware, and four or five ounces of the powder of charcoal of beech. This mixture being moistened with half a pint of water, is introduced into a Hessian retort; the matter is assayed, by making a portion red-hot in a crucible: if it emit a violet flame, with a smell of garlick, it is a proof that phosphorus will be afforded. The retort is placed in a furnace built on purpose, and a large receiver is adapted, two-thirds full of water; the receiver must have a small hole pierced in it; and M. Hellot considers this as one of the most necessary circumstances



to insure success. Three or four days after the apparatus has been put together, a fire is made, so as very gradually to dry the furnace and the lutes. The fire is raised by degrees to the most extreme heat, and kept up in that state for about twenty hours; the phosphorus does not come over till about fourteen hours after the commencement of the operation, which in the whole lasts twenty-four hours. A large quantity of concrete volatile salt first rises, which is partly dissolved in the water of the receiver: the volatile, or aeriform phosphorus, first passes in luminous vapours; the true phosphorus next comes over, in the form of an oil, or resembling melted wax. When no more passes over, the apparatus is left to cool for two days; the receiver is then unluted, and water is added to loosen the phosphorus adhering to the sides; the phosphorus is then melted in boiling water, and cut into small pieces, which are introduced into the necks of matrasses, cut towards the middle of the body into the form of a funnel, and plunged in boiling water; the phosphorus melts, is purified, and becomes transparent, by the separation of a blackish matter, which rises to the top; it is afterwards plunged in cold water, by which it is congealed, and is thrust out of the necks of the matrasses by a small stick introduced at the lesser end. Such, in short, is the process

cess described by Hellot. The length of the operation deterred chemists from repeating it, excepting Rouelle the elder, who performed it several times with success in his chemical lectures.

In the year 1743, Margraaf published, in the Memoirs of the Academy of Berlin, a new method of making a considerable quantity of phosphorus more readily than had been done before his time. According to his process, the plumbum corneum remaining after the distillation of four pounds of minium and two pounds of sal-ammoniac, is mixed with ten pounds of the extract of urine of the consistence of honey; half a pound of charcoal in powder being added, the mixture is dried in an iron pot till it is converted into a black powder; this powder is distilled in a retort, to obtain, by a gradual fire, the volatile alkali, fetid oil, and sal-ammoniac. Care must be taken to urge the fire no more than till the retort is moderately red. The black and friable matter of this distillation is that which affords the phosphorus; it is assayed by throwing a small quantity on heated coals; if it emits a smell of garlick, and a blue phosphoric flame, it is a proof that it has been well prepared. An earthen retort of Hesse or of Picardy, is filled to three-fourths of its capacity with this substance, well coated with lute; this vessel is placed in a reverberatory

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furnace, with a dome and iron chimney of six or eight feet in height; a middle-sized receiver, pierced with a small perforation, and half filled with water, is to be adapted, and the place of junction must be luted with fat lute, covered with fillets dipped in white of egg and lime; a brick wall is built up between the furnace and the receiver, and the whole apparatus is then left to dry for a day or two. The distillation is then begun, by a fire very gradually raised, and the operation lasts from six, to eight or nine hours, according to the quantity of matter exposed to distillation. The phosphorus is rectified by re-distillation by a very gentle heat, in a retort of glass, with a receiver half filled with water. Most chemists have repeated the process of Margraaf with success; and it was the only process used, till the late discovery of separating the phosphoric acid from bones, as we shall observe when we come to speak of these organs.

It may be observed, that the process of Margraaf differs from that of Hellot only in the addition of the plumbum corneum, and the dividing the operation into two; but the most valuable part of the operation of the learned chemist of Berlin, consists in his determining which of the substances contained in urine serves to form the phosphorus. By distillation of a mixture of the fusible salt and charcoal, he obtained a very fine

fine phosphorus, and observed that urine, from which this salt has been extracted, affords scarcely any of this combustible substance. It therefore follows, that phosphorus is formed by means of one of the constituent parts of fusible salt; and this substance is easily obtained, by distilling two parts of the glass obtained by this salt, decomposed in a retort or a crucible, with one part of charcoal in powder. This operation requires much less time, and a less degree of heat, than those we have before described, since, according to M. Proust, the phosphorus comes over at the end of a quarter of an hour. It is doubtless the best process for procuring the phosphorus of urine; but several objections may be made to it: 1. The vitreous residue of the decomposition of the ammoniacal phosphat by fire, not being the pure phosphoric acid, but combined with phosphat of soda, which is not decomposable by charcoal, the quantity of phosphorus obtained by employing this residue is but very small; since an ounce affords no more than a drachm, and frequently a less quantity. 2. Because, when a large quantity of fusible salt is obtained by evaporation and cooling, it is found to be mixed with a great quantity of the phosphat of soda, which does not afford phosphorus. It may from these two observations, be conceived why so small a



quantity of this combustible substance is obtained by the distillation of fusible salt with charcoal: fusible salt alone, of the mixture of the ammoniacal phosphat and phosphat of soda, distilled with charcoal and muriate of lead, or plumbum corneum, may perhaps afford a larger quantity, since the latter appears to have the property of decomposing phosphat of soda.

Phosphorus obtained by all the processes we have described, is always the same substance. When very pure it is transparent, and of a consistence resembling that of wax; it crystallizes, by cooling, in laminæ, which are brilliant, and as it were micaceous; it melts in hot water, long before the fluid becomes boiling hot; it is very volatile, and by a gentle heat rises and comes over in the form of a thick fluid. When in contact with air, it emits a fume from every part of its surface; and this vapour, which smells strongly like garlick, appears white in the day-time, but is very luminous in the dark. The slow combustion of phosphorus consists in this disengagement, and if it be left for a certain time exposed to the air, it consumes by degrees, and leaves a peculiar acid, whose properties we shall hereafter examine. This slow combustion cannot be performed, unless the phosphorus be in contact with the air; and in order that it may be very luminous, a heat of from twelve to

to fifteen degrees of Reaumur's thermometer, or about sixty-three degrees of Fahrenheit's, is required, though it takes place at a lower temperature. The inflammation does not produce heat, nor set any combustible body on fire; but when phosphorus is exposed to a dry heat, of twenty-four degrees of Reaumur, or eighty-six of Fahrenheit, it takes fire with decrepitation, burns rapidly, with a very lively white flame, mixed with yellow and green, and destroys all the combustible bodies it touches with the greatest facility. The vapours it emits are then very abundant, white, very luminous in the dark, and leave a different residue in each of these combustions: the first affords a liquor, which weighs more than twice as much as the phosphorus made use of, and is known by the name of the phosphoric acid: the second leaves a thick matter, of a reddish white, which emits white vapours, till it has attracted a sufficient quantity of the moisture of the air to become fluid; it then resembles the acid and fluid residue of the first combustion, or slow inflammation; yet these two acids present certain differences in their combinations, as Margraaf has observed, and as M. Sage has likewise pointed out, in the *Memoirs of the Academy for the year 1777*. We shall speak more fully respecting these differences in the history of the phosphoric acid.

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The combustion of phosphorus was considered by Stahl as the disengagement of phlogiston, which he supposed to be combined with the muriatic acid \* in this inflammable substance. M. Lavoisier, in order to discover what happens in this combustion, burned, by the concentrated rays of the sun, phosphorus under a glass vessel, inverted over mercury; he observed that no more than a certain quantity can be burnt in a determinate bulk of air, and that this quantity consists of one grain of phosphorus for sixteen or eighteen cubic inches of air; that after this combustion, the phosphorus is extinguished, and the air is no longer capable of burning new phosphorus; that the volume of the air is diminished, and the phosphorus dissipated in white snowy flakes, which adhere to the sides of the vessel. These flakes are twice and a half the weight of the phosphorus used, and this augmentation of weight corresponds exactly to that which the air has lost, and depends intirely on the absorption of the oxygenous principle by the

\* Stahl has affirmed in several of his works, that by combining the marine acid with phlogiston, phosphorus may be made. Margraaf made a series of experiments with different combinations of the marine acid, treated with combustible bodies, and never succeeded in producing phosphorus; he has likewise shewn, that the acid which remains after the combustion of this substance differs very much from that of marine salt; and this is at present universally admitted by all chemists. Note of the Author.

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phosphorus: in fact, the white flakes are the concrete phosphoric acid, formed by the combination of phosphorus with the portion of pure air contained in the atmospheric air, which has served to burn this inflammable substance. This theory is the same as that of sulphur, and it is therefore unnecessary to repeat what has been said respecting this substance in the mineral kingdom.

If phosphorus be liquified in hot water, and vital air be passed through it under water, it burns, and is reduced to the state of phosphoric acid.

Though phosphorus be not soluble in water, yet it is changed by it in process of time, and loses its transparency; becomes yellow, and covered with an efflorescence and coloured powder; the water becomes acid, and appears luminous when agitated in the dark; the phosphorus is therefore slowly decomposed.

The caustic fixed alkalis dissolve phosphorus, by the assistance of a boiling heat; during this combination, a fetid gas, discovered by M. Gengembre, which has the singular property of taking fire and exploding, by the contact of atmospheric air, and still more readily by the contact of vital air, is disengaged: this elastic fluid consists of phosphorus dissolved in inflammable gas.

The vitriolic acid, dissolved with phosphorus in a retort, decomposes it almost entirely,



tirely, but without inflammation; the concentrated nitrous acid attacks it with violence, and suddenly inflames it. When this experiment is made in a retort, with nitrous acid not very concentrated, the phosphorus burns by degrees, seizes the oxygenous principle of the nitrous acid, and forms the phosphoric acid. This process was described by M. Lavoisier in 1780.

The muriatic acid, though super-saturated with vital air, does not attack phosphorus.

Nitrous salts inflame it with great rapidity, by the assistance of a low heat.

Sulphur and phosphorus combine, according to Margraaf, by fusion and distillation, and compose a solid substance, of an hepatic odour, which burns with a yellow flame, swells in water, to which it communicates acidity, and the smell of liver of sulphur; properties which certainly shew a peculiar re-action between these two bodies.

Phosphorus does not unite so readily with metals as sulphur does, though it resembles that substance in many of its properties. Margraaf attempted to make these combinations, by distilling the several metallic substances, each with two parts of phosphorus: no peculiar phenomena were presented but by arsenic, zink, and copper; all the other metals were not changed by the phosphorus, which was partly burnt or sublimed

lined in the receiver, without having experienced any remarkable change.

Phosphorus, sublimed with arsenic, afforded this celebrated chemist a substance of a beautiful red, similar to realgar.

Zink, distilled twice successively with this combustible substance, afforded yellow, pointed, and very light flowers; these flowers exposed to the fire under a red-hot muffle, burned and afforded a transparent green glass, similar to that of borax.

Copper, treated in the same manner with phosphorus, lost its brilliancy, and became very compact; its weight was increased ten grains in the half drachm, and it took fire, and burned, on being applied to a flame.

The Marquis de Bouillon and M. Sage have described a remarkable alteration which phosphorus undergoes in metallic solutions: the first of these chemists has discovered, that small sticks of phosphorus, plunged in solutions of gold, silver, copper, &c. became gradually covered with a kind of sheath of shining metal: these valuable experiments shew that the phosphorus has a stronger affinity with the oxygenous principle than many metals, and is capable of reducing their calces. Bergman has established the fact, that the arsenical acid becomes black, and is converted to the state of metallic arsenic, when heated with phosphorus, which becomes phosphoric acid, in proportion as  
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it takes the oxyginous principle from the arsenic.

Phosphorus dissolves in all oils, and renders them luminous. Spielman has discovered that it dissolves in spirit of wine, and that this solution emits sparks when it is poured into water: part of the phosphorus is precipitated in a white powder during this operation.

Phosphorus is not yet used either in medicine or in the arts. Messrs. Menzies, Morgenstern, Hartman, &c. affirm, that they have experienced very happy effects in malignant and bilious fevers, when the strength has been exhausted, and in the miliary fever; others have recommended it in the scarlet fever, the peripneumony, rheumatic pains, epilepsy, &c.; but though several dissertations have already appeared in Germany on the medical virtues of phosphorus employed internally, nothing can yet be established concerning it, till experience has ascertained its virtues with greater certainty.

## C H A P. XIX.

## Concerning the Phosphoric Acid.

THE phosphoric acid has been thus called, because it has been thought to exist, ready formed, in phosphorus, from which it was obtained by combustion; but M. Lavoisier has proved, that this salt is a combination of phosphorus with the base of pure air, or the oxygenous principle. To obtain this acid, four processes may be used: the first consists in burning phosphorus rapidly, under glass vessels filled with atmospheric air, inverted over mercury; the combustion being begun, either by a burning glass, or a red-hot iron wire; it is necessary first to moisten the inside of the glass with a small quantity of water. This process, directed by M. Lavoisier, affords phosphoric acid in a very short time, but mixed with a small quantity of phosphorus, not decomposed: vital air may be used for this combustion, but the inflammation is then so rapid and violent, that it often causes the glasses to fly in pieces. The second process, invented by Messrs. Wolfe and Pellerier, is performed by passing a current of vital air through phosphorus melted



melted under water. In the third method, contrived by M. Lavoisier, phosphorus is burnt, by means of the nitrous acid, rather more than moderately strong.

The fourth process, or slow combustion, improperly called the formation of the phosphoric acid per deliquium, is very well described by M. Sage. Sticks of phosphorus are placed in a glass funnel, whose neck is received in a bottle, and its base covered, but not closely; a tube of glass is put into the neck of the funnel, in order to prevent the phosphorus from falling through; and to give a passage to the air of the vessel, displaced by the phosphoric acid, care must be taken that the sticks of phosphorus do not touch each other, and that the temperature of the place does not exceed sixty degrees; as without these precautions, the phosphorus may deflagrate: by this method, an ounce of phosphorus affords three ounces of an acid, which is collected in the bottle, with a small quantity of water, added by a little at a time.

These four processes afford the phosphoric acid in two different states, accordingly as it contains phosphorus not decomposed, or intirely burnt, and saturated with the oxygenous principle. These two acids exhibit phenomena, with respect to each other, similar to those exhibited by the vitriolic and sulphureous acids: this is the reason of the  
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small difference between the results obtained by Mess. Sage and Lavoisier, in the combinations of this acid, as related in the Memoirs of the Academy for 1777. They may be brought into the same state of purity by distillation with spirit of wine, which takes away the portion of phosphorus they may contain.

The phosphoric acid, obtained by the slow combustion, contains but a very small quantity of unburnt phosphorus: it is a colourless fluid, without smell, of an acid taste, and reddens the syrup of violets: when exposed to the action of fire in a retort, pure phlegm comes over, the acid becomes concentrated, and heavier than even the vitriolic acid, and gradually grows solid, white, and soft, like an extract. Lastly, when urged by a violent heat, it melts into a transparent, hard, very elastic and insoluble glass, which no longer presents the acid character, and is by M. de Morveau considered as a pure acidifiable base: but it is difficult to admit this opinion, because vital air is not disengaged during the fusion. This solid and vitreous state appears to depend on a more intimate combination between the acidifiable base and the oxygenous principle; and the want of acidity in this glass is no more to be wondered at, than the privation of its acid property, which the muriatic acid suffers by combination with an excess of the

oxyginous principle. This idea respecting the more intimate fixation of the base of air in the acidifiable base of the phosphoric acid, is confirmed by the difficulty of obtaining phosphorus from it by the addition of charcoal, and by the necessity of giving a high temperature to the mixture for that purpose.

If the phosphoric acid, obtained either by deflagration, or by the slow combustion of phosphorus, be heated in an open vessel, small flames arise, from time to time, which doubtless are produced by a portion of phosphorus not yet intirely burned. In these circumstances, the acid becomes concentrated and dry, and at last melts, in the same manner as when treated in a close vessel.

The concentrated phosphoric acid very quickly attracts the moisture of the air; it unites to water with heat, combines with a great number of substances, and presents peculiar phenomena in these combinations.

The phosphoric acid does not appear to act on quartzose earth, neither by the dry nor the humid way, according to the experiments of Bergman and De Morveau; but it acts on glass, as appears from the experiments of Ingenhousz and Priestley. When urged by the blow-pipe, together with clay, it boils; and the phosphoric acid, melted in Hessian crucibles, gives them a vitreous transparent glaze, as M. de Morveau remarks.

It unites with ponderous earth, and appears

appears to prefer it to all other bases, except lime, according to Bergman's table of attractions. The properties of barytic phosphat are not yet known.

The phosphoric acid dissolves cretaceous magnesia with effervescence; the salt it forms with this substance is of difficult solubility; a well saturated solution, after twenty-four hours repose, affords crystals in very slender, small, flat needles, several lines in length, and obliquely cut off at each end; when exposed to a gentle heat, they become reduced to powder: the vitriolic acid decomposes this salt, according to Lavoisier.

The phosphoric acid, poured into lime-water, precipitates it in the form of a salt scarcely at all soluble, which does not effervesce with acids, and in which the acid is always predominant: this salt reddens blue paper, is decomposed by the mineral acids, and even by the caustic fixed alkali, and affords, with the nitrous solution of silver, a precipitate of the colour of wine lees; and with that of mercury, a white pulverulent precipitate. This salt is of the same nature as the residue of burned bones. An excess of the phosphoric acid renders the calcareous phosphat soluble in water; but it is precipitated by magnesia, lime, caustic fixed alkali, and even by the volatile alkali, all which deprive it of its excess of acid. The calcareous phosphat is not decomposed by caustic alkalis, though it is by the same alkalis combined with fixed air.



The phosphoric acid, saturated with vegetable alkali, forms a very soluble salt, which, by evaporation and cooling, affords tetrahedral crystals terminated by four-sided pyramids, whose sides correspond with those of the prisms: this phosphat of pot-ash is acid, and dissolves much more completely in hot than in cold water; it expands on hot coals, and melts but with difficulty; when melted, it loses its saline taste; it precipitates the nitrous solution of silver, of a white colour, and that of mercury of a yellowish white: it is decomposed by lime-water, which has a stronger affinity than the vegetable alkali to the phosphoric acid.

The mineral alkali, united with the phosphoric acid, produces a salt of an agreeable taste, similar to that of the muriate of soda, or common salt. The phosphat of soda does not crystallize; it is reduced, by evaporation, into a gummy deliquescent matter, tenacious and adhesive, like turpentine. This salt was prepared by M. Lavoisier, with the acid obtained by the deflagration of phosphorus. M. Sage affirms that the salt prepared with the acid of phosphorus, obtained by the slow combustion, and combined with soda, affords crystals which are not deliquescent.

Ammoniacal phosphat, formed by the combination of the phosphoric acid with the volatile

volatile alkali, is more soluble in hot water than in cold; and by cooling affords crystals, which, according to M. Lavoisier, resemble those of alum. This salt must differ from that obtained from evaporated urine, because the latter always contains a small quantity of the phosphat of soda.

The phosphoric acid decomposes the vitriolic, the nitrous, and the alkaline muriates, by the dry way, and disengages their acids, by reason of its fixity; but it yields its bases to them by the humid way.

The phosphoric acid, in its fluid state, acts only on a small number of metallic substances: it readily dissolves zink, iron, and copper; these solutions do not afford crystals by evaporation, except that of iron, which appears capable of crystallizing; the others are reduced into ductile and soft masses, resembling extracts: if they be urged by heat, they throw out sparks, and appear to form true phosphorus. Margraaf and the academicians of Dijon have examined fully the action of this acid on metals and semi-metals.

The phosphoric acid likewise precipitates certain metallic solutions; such as those of mercury, silver, and lead, by the nitrous acid.

This acid re-acts on oils, and exalts their smell; to such oils as have no smell it gives

a sweet and as it were ethereal smell; it thickens some oils.

When distilled from charcoal, in its dry state, it affords phosphorus.

When heated in a retort with spirit of wine, it afforded the academicians of Dijon a liquor strongly acid, of a penetrating and disagreeable smell, which burnt with a small quantity of smoke, and exhibited some of the properties of ether. The phosphoric acid was rendered volatile in this experiment, as appears from the acidity of the product. M. Lavoisier has observed, that heat is produced in this mixture; yet most chemists consider the phosphoric acid as insoluble in spirit of wine. Margraaf, Rouelle, Scheele, Wenzell, Laffone, Cornette, and the Duc de Chaulnes, have directed the use of spirit of wine to purify and separate the phosphoric acid from the different foreign substances it may contain. Lastly, the phosphoric acid dissolves the phosphat of soda, forming with it a kind of triple salt, which by fusion affords a hard, insipid, insoluble, non-deliquescent, and opaque glass, similar to that afforded by fusible salt alone, when urged by the fire.

We must likewise observe, that the phosphoric acid, which was formerly supposed to be peculiar to urine, exists in many animal matters, as we have already seen, and will hereafter be pointed out. Margraaf discovered

discovered it in vegetables, and M. Berthollet has found it in all those which afford volatile alkali by distillation. It has been found in many minerals, and in particular in lead and iron, in which it seems to have been afforded by the decomposition of animal substances.

This acid has not yet been applied to any use; it might be, perhaps, medically used with success, on account of its analogy with animal matters.

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## C H A P. XX.

### Concerning the soft and white Parts of Animals and their Muscles.

**A**Lthough the analysis of the solid parts of animals be less advanced than that of their fluids, yet we begin to acquire some knowledge of the different matters which compose them; it more especially ascertained that the difference between their texture or formation indicates a difference in their principles. This assertion will be confirmed by an examination of the soft and white parts, and also of the muscles and bones.

All the soft and white parts of animals,

B b 4

such



such as the membranes, the tendons, the aponeuroses, the cartilages, the ligaments, the skin, contain, in general, a mucilaginous substance very soluble in water, and not at all soluble in spirit of wine, which is known by the name of jelly. To extract this jelly, the animal parts must be boiled in water, and the decoction evaporated till it becomes a solid and tremulous mass by cooling; a stronger degree of evaporation affords a dry, brittle, transparent substance, known by the name of glue.

Glue is prepared with all the white parts of animals; the skin, the cartilages, and the fat of oxen, are used to prepare the strong glue of England, Flanders, Holland, &c. The skins of eels afford the base of gold size, and with old white leather gloves and parchment, a kind of glue used by painters, &c. is made. There are scarcely any animals, whose tendons, cartilages, nerves, and more especially the skin, will not serve to prepare these different kinds of glue.

It must be here observed, that glues differ from each other in their consistence, taste, smell, and solubility: there are some which readily become soft in cold water, others are not dissolved but in boiling water. The best glue is transparent, of a yellow brownish colour, without smell and taste, intirely soluble in water, with which it forms a viscid uniform fluid that preserves an equal degree

degree of tenacity and transparency in all its parts as it dries.

Animal jelly does not differ from glue properly so called, but in its possessing a less degree of consistence and viscosity. The first is more especially obtained from the soft and white parts of young animals; it is likewise found in their flesh, muscles, skin, and bones. Glue is obtained only from animals of a greater age, whose fibres are stronger and drier. These two substances however, exhibit the same chemical properties; and therefore we shall speak of the jelly afforded by the cartilages or membranes of veal.

In its natural state, jelly has no smell, and but a faint taste: by distillation in the water-bath, it affords an insipid and inodorous phlegm, capable of putrefaction; in proportion as it loses its water, it assumes the consistence of glue, and when intirely dried, it resembles horn; when exposed to a stronger fire, with access of air, it swells, liquifies, and becomes black, emitting an abundant fume of a fetid smell; it does not take fire without difficulty; and by a violent heat by distillation in a retort, it affords an alkaline phlegm, an empyreumatic oil, and a small quantity of ammoniacal chalk; it leaves a large mass of charcoal, difficult to incinerate, which contains muriate of soda, and calcareous phosphat.

Jelly,

Jelly, when exposed to a hot and moist air, becomes first acid, and soon after putrid.

Water dissolves it in all proportions; acids, and especially alkalis, dissolve it readily; the nitrous acid disengages mephitic. Most of these properties shew a resemblance between jelly and the insipid vegetable mucilages, if we except those of affording volatile alkali by heat, and mephitic by the nitrous acid: and may not these last be attributed to a portion of lymphatic matter or serum, which the water extracts at the same time with the gelatinous substance, especially when jellies or glues have been prepared by strong decoction long continued?

The muscles of animals are formed of a parenchymatous and cellular substance, in which different humours are contained, partly concrete, and partly fluid. These humours are composed, 1. Of a red and white fluid. 2. Of a gelatinous mucilage. 3. Of a mild oil, of the nature of fat. 4. Of a peculiar extractive substance. 5. Lastly, of a saline matter, whose nature is but little known. The analysis of flesh, when distilled in a water-bath, affords an insipid water; and in a retort an alkaline phlegm, an empyreumatic oil, and concrete volatile alkali; and which leaves a charcoal, from which a small quantity of fixed alkali, and febrifuge or marine salt, are obtained by incineration: these properties discover

discover nothing which can be depended on respecting the nature of the principles. It is therefore necessary to have recourse to methods, by which these substances may be extracted without alteration, and afterwards examined separately.

M. Thouvenel, who first observed these different substances, forced out the fluids contained in the muscular sponge by pressure, coagulated the lymph by the action of heat, and obtained the salt by evaporation. He distilled and separated the gelatinous mucilage by means of water, and used spirit of wine to separate the salts and extract from the jelly. The accurate separation of these different matters is, in general, very difficult; because they are all soluble in water, and spirit of wine dissolves the saponaceous extract, and a part of the salt at the same time. The process which succeeds best, appears to be the following: The flesh is first washed in cold water, which takes up the colouring lymph with a part of the salt; the residue being digested in spirit of wine, gives out all the extractive matter, and a portion of salt to that menstruum. Lastly, the remaining mass being boiled in water, gives out its gelatinous part, and likewise those portions of extract and salt, which escaped the action of the former menstrua. By slowly evaporating the water first employed, without heat, the lymph coagulates, and is separated by the filter, and  
the



the saline matter may be obtained by a succeeding evaporation; the spirit of wine likewise being evaporated, affords the coloured extractive matter; and lastly, the decoction affords the jelly and the fat oil which swims at the surface, and fixes by cooling. After the extraction of these different substances, nothing remains but the fibrous matter, which is white, insipid, insoluble in water, contracts and curls up by heat; and by distillation in a retort, affords much volatile alkali, and a very fetid oil. A large quantity of mephitic is obtained from this substance by the action of nitrous acid. In a word, it possesses the characters of the fibrous part of the blood; it therefore appears to be proved, that the muscular organ is the reservoir, in which the action of the vital powers deposits the fibrous matter, which becomes concrete by rest; and which appears to form the basis of that animal property which physiologists call irritability.

Nothing remains now, but to examine the properties of each of the substances of which the flesh of animals are composed, in order to ascertain its nature with accuracy.

The lymph, the jelly, and the fat part are already known; the first perfectly resembles the serum of blood. We must observe, that it is this substance, which coagulating by the heat of water, in which animal food is boiled, produces the scum which is  
carefully

carefully taken off. This scum is of a dirty red brown, because the red lymph is altered by the heat of ebullition. The jelly extracted from flesh causes soups, prepared with the flesh of young animals, which contains it in greater quantities than that of older animals, to assume the form of a tremulous mass. It is absolutely similar to that which constitutes the soft and white parts of animals, whose properties have been explained in the preceding article. The fat substance which forms the flat and round drops that float on the surface of broths and soups, and become solid by cooling, has all the characters of grease. It only remains, therefore, to examine the extractive matter, and the solid, obtained in the analysis of the muscles.

That which M. Thouvenel calls the mucous extractive substance, is soluble in water, and spirit of wine; it has a strong taste, whereas jelly has none. When it is very concentrated, it is acrid and bitter; and it has a peculiar aromatic smell, which fire developes. This substance gives the colour to soups, as well as the taste and agreeable smell which are well known. When they are too much evaporated, or the quantity of flesh is very considerable in proportion to the water, soups are high coloured, and more or less acrid. The action of fire developes and exalts the taste of this extractive substance, so as even to give it the taste of sugar,  
or

or caramel, as is observed on the surface of roast meat, which is commonly called the brown. If we further examine the properties of this extractive substance when evaporated to dryness, we observe, that its taste is acrid, bitter, and saline; that it swells and liquifies on hot coals, emitting a penetrating acid smell, similar to that of burnt sugar; that it attracts moisture when exposed to the air, and acquires a saline efflorescence on its surface; that it becomes sour, and putrefies in a warm air, when diluted with a certain quantity of water; and lastly, that it is soluble in spirit of wine. All these characters indicate a resemblance between this acid and the saponaceous extracts, and saccharine matter of vegetables.

The nature of the salt which crystallizes in the slow evaporation of the decoction of flesh, is not yet perfectly known. M. Thouvenel obtained it in the form of down, and that of irregular crystals. This chemist thinks that it is a perfectly neutral salt, consisting of pot-ash, and an acid which has the character of the phosphoric acid in frugivorous quadrupeds, and that of the muriatic acid in carnivorous reptiles. Though this salt may be considered as unknown, till a sufficient quantity shall have been collected, to admit of its being examined with accuracy; yet it is very probable that it consists of the phosphoric acid, combined with the mineral  
and

and vegetable alkali, and mixed with calcareous phosphat. These salts are indicated even with excess of acid, as in urine, by the test of lime-water and volatile alkali, which form white precipitates in the decoction; and the nitrous solution of mercury, which affords a rose-coloured precipitate with the same liquor.

We may likewise add, that the most abundant substance, and that which constitutes the proper character of muscular flesh, is the fibrous part. This matter is deposited by the blood, which contains it in a large proportion, and appears to be of great importance in the animal economy. Its nature and properties have not been sufficiently attended to in physiological inquiries respecting the quantity and weight of muscular flesh compared with the other organs. The characters which distinguish this animal matter are, 1. That it is not soluble in water. 2. It affords a larger quantity of mephitic by the nitrous acid, than any other substance. 3. It afterwards affords the saccharine acid, and that which M. de Morveau calls the malusian acid. 4. It quickly putrefies when moistened, and affords much concrete volatile alkali by distillation.

These properties shew, that it is formed by a fat or oily substance combined with mephitic, together with the phosphat of soda, and the calcareous phosphat, which  
are



are separated by the action of the nitrous acid. I have considered the purposes which are answered in the animal economy by this fibrous matter, in a particular Memoir inserted among those of the Royal Society of Medicine.

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C H A P. XXI.

Concerning the Bones of Animals.

**T**HE bones are the support of all the other organs of animals, the bases on which all the soft parts rest. These hard substances cannot be considered as passive in the animal economy, they are true secretory organs, which separate from the blood and other humours a peculiar saline substance, of which they are the reservoir, or place of deposition.

The bones in all animals, from man to insects and worms, differ in their texture, solidity, relative position, and probably in their nature. Chemical analysis has not yet decided respecting this last point; but it can hardly be supposed, that the bones of men and quadrupeds are of the same nature as the soft; and flexible bones of fishes, reptiles, and more especially the corneous coverings of

of insects, as well as the calcareous shells of reptiles.

The general view which we shall here take of the bones of animals, does not permit us to dwell on such differences as chemists have not yet sufficiently ascertained by experimental inquiry. The bones of men and of quadrupeds, which alone have been hitherto examined by chemists, are not earthy matters, as was formerly supposed: they contain a certain quantity of gelatinous matter, dispersed in small cavities, formed by the interval between the solid parts which compose their texture; and the solid parts themselves, though they seem to resemble earthy substances by their insolubility and firmness, have been for several years past acknowledged to be a true neutral salt, consisting of phosphoric acid and lime.

Bones exposed to fire with the contact of air, quickly take fire, by virtue of a certain quantity of medullary fat which they contain. By distillation in a retort, they afford an alkaline phlegm, a fetid empyreumatic oil, and much concrete volatile alkali: their coal is compact, and difficultly incinerated, and leaves a white residue, which, by washing in cold water, affords a small quantity of cretaceous soda; hot water afterwards takes up a certain quantity of selenite: the residue of these lixivia is insoluble in water, and is

the calcareous phosphat discovered by M. Gahn of Stockholm, in 1769. Bones calcined in a furnace in the midst of the charcoal, remain luminous in the dark: by a strong heat they are semi-vitrified and reduced into a hard very white kind of porcelain.

Water, in which bones, reduced into small pieces or rasped, are boiled, becomes loaded with a substance which renders it viscid, and is a true gelatinous matter.

The cretaceous alkalis decompose the calcareous phosphat, which forms the base of bones. This decomposition was discovered by the chemists of the academy of Dijon: they inform us, that they produced it by fusing a mixture of the powder of calcined bones, and cretaceous vegetable alkali.

Acids act on bones, and decompose the calcareous phosphat they contain; by which means it was that Scheele, in the year 1771, succeeded in preparing phosphorus with bones. This chemist dissolved bones in the nitrous acid, which seized the lime, and formed calcareous nitre; the salt remaining in solution, together with the disengaged phosphoric acid: on this mixture he poured vitriolic acid, which seizing the lime of the calcareous nitre formed selenite; this salt being precipitated on account of its insolubility, was separated by the filter. Lastly, he distilled

distilled in a retort the filtered liquor containing the nitrous and phosphoric acids, and when the latter by the evaporation was reduced to the consistence of syrup, he mixed it with charcoal, to obtain phosphorus. Messrs. Rouelle, Poulletier, de la Salle, and Macquer, were the first who repeated these valuable experiments at Paris. Lastly, the Academicians of Dijon, Messrs. Rouelle, Proust, and Nicolas de Nancy, communicated their inquiries and processes. Many other chemists have examined the several solid substances, and among the latter Mr. Bernierd obtained phosphoric acid from fossil bones, from the bones of the whale, the elephant, the porpoise, the elk, the ox, the teeth of the sea cow, and the human species, and the grinders of the elephant; and he observed that all these bones afforded the same substances, and contained phosphoric acid in different quantities. The Marquis de Bullion has likewise obtained phosphoric glass from ivory, and from the bones of fishes.

The process of the chemists of Dijon and of M. Nicholas is at present mostly used to obtain the phosphoric acid from bones: the bones are calcined to whiteness, reduced to powder, sifted and mixed in a stone-ware pan, with an equal portion of oil of vitriol, a sufficient quantity of water being added, to give the whole the consistence of clear soup; this mixture being left at rest for several hours,



grows thick; it is then poured on a filter of double cloth, and washed with water, till the fluid which passes through is tasteless, and no longer precipitates lime-water; in this case it is certain, that the residue contains no more disengaged phosphoric acid: the filtered water being evaporated deposits gradually a white substance which is selenite, and must be separated by a filtration, care being taken to wash it with a sufficient quantity of water to carry off the phosphoric acid that may adhere to it. These filtrations are to be repeated till the fluid deposits no more precipitate: it is then evaporated to the consistence of honey, or a soft extract, and at that time has a brown colour and greasy aspect. If this be gradually heated in a crucible till it ceases to emit a sulphureous, and as it were aromatic smell, and no longer boils, it acquires a semi-vitreous consistence with an acid taste, and attracts the humidity of the air: a greater degree of heat fuses it into a transparent, hard, insipid, insoluble matter, which has no acidity. When phosphorus is intended to be made, it is not necessary to continue the heat till the residue becomes converted into the form of an insoluble glass, because it then would not afford phosphorus, but by a strong heat and much less readily, than while it is still soft and deliquescent. To convert it into  
phosphorus

phosphorus it is pulverized, mixed with one third of its weight of very dry charcoal, and the mixture introduced into an earthen retort, to which a receiver half filled with water, and pierced with a small aperture, or terminating in a syphon connected by the apparatus of Woulfe is adapted; the fire is raised by degrees till the retort is heated to whiteness, at which time the phosphorus passes over in drops, and the operation lasts in the whole from five to seven or eight hours, according to the quantity of the matter distilled, and the heat the furnace is capable of giving. From six pounds of bones, twenty ounces, or a little more, of the vitriform residue is usually obtained; and this residue affords about three ounces of very good phosphorus, and a few drachms of phosphorus half decomposed.\*

\* It is not necessary, for the making of phosphorus, to carry the evaporation further than till the matter has acquired the consistence of syrup, which may be conveniently performed in a copper vessel; and instead of a receiver, the neck of the retort may be plunged simply in water contained in an open basin. Care must be taken that the neck of the retort is not plunged so deep as that the water may rise into the body of the vessel, when absorption takes place, but that the fluid in the basin may by its fall suffer air to enter; in this case a small quantity of the phosphorus within the neck of the retort may be burned, but the quantity thus lost is very inconsiderable. Phosphorus is usually purified by straining it through a leather bag immersed in hot water; but the best method of clearing phosphorus from the impurities of the first distillation, is to re-distil it with a very gentle heat. T.

This product obtained from bones by the vitriolic acid, as well as the residue of the ammoniacal phosphat, decomposed by fire, does not consist of the pure phosphoric acid, since it affords at most one-fifth of its weight of phosphorus: it appears to contain a certain quantity of phosphat of soda. If this salt remains mixed with calcareous phosphat, arising from a small quantity of selenite, it usually melts with the phosphat, and forms a very hard opaque glass, which resists the action of all menstrua.

M. de Morveau has proposed a method of obtaining very pure ammoniacal phosphat, with the phosphoric acid of bones; for this purpose, calcined bones must be dissolved in the diluted vitriolic acid, and the solution essayed by that of bones in the nitrous acid, in order to be sure that no disengaged vitriolic acid remains, the portion of calcareous phosphat it contains is precipitated by the caustic volatile alkali, as M. Wiegleb practises in his process; after which the liquid is filtrated, and suffered to evaporate spontaneously. Very beautiful crystals of ammoniacal phosphat are obtained, mixed with a small quantity of phosphat of soda, which separates by efflorescence. The calcareous phosphat, which remains on the filter, may be decomposed for the making of phosphorus.

## C H A P. XXII.

Concerning different Substances used in Medicine and the Arts, which are obtained from Quadrupeds, Cetaceous Animals, Birds, and Fishes.

IF we proposed to make an accurate and ample history of all the substances afforded by animals, and applied to medical purposes, or used in the arts, it would occupy more of our time than has already been applied to the animal kingdom, more especially if we were to treat of the several animal matters, which empiricism, or ignorant credulity, have formerly introduced into medicine as celebrated remedies, but which at present are regarded as intirely usefess. We do not, however, propose to mention more than the principal of these substances, which medical and chemical experience has shewn to possess valuable properties, or which are of the greatest utility in the arts.

Among the matters afforded by quadrupeds, we select castoreum, musk, and hartshorn. The white substance produced by a cetaceous animal, and known by the name of spermaceti, will be treated of apart.



Among the products of birds, we shall exhibit the analysis of eggs ; among oviparous quadrupeds and serpents, the tortoise, the frog, and the viper will claim a separate article. Ichthyocolla, or isinglass, is the only product of fishes which we shall consider. The class of insects will afford a greater number of objects : cantharides, ants, millipedes, honey, wax, the silk worm, and silk, gum lac, kermes, cochineal, and crabs eyes; and lastly, we shall conclude our examination of the products of the animal kingdom, by those of coral and corallines, which belong to the class of worms and polypi.

From this short enumeration, it will be seen, that we pass over in silence a great number of other matters, formerly used in medicine ; such are, among others, ivory, unicornu, the teeth of the hippopotamus, of the beaver, of the boar, the bones of a stag's heart, the feet of the elk, bezoar, civet, and the blood of the wild goat, among quadrupeds ; the swallow's nest, goose grease, peacock's dung, and the membrane of the stomach of poultry, among birds ; the toad, and the scincus among oviparous quadrupeds ; the gall and stones of carp, the liver of the eel, the stones of perch, the jaws of the pike, among fishes ; the scarabæus, spider's-web, the meloe, or proscarabæus, and the claws of crabs among insects. Lastly, shell-worms, snails, oyster-shells, nacles of pearl,  
and

and bones of cuttle-fish, among the naked, or covered worms. Among all these substances, some have only imaginary virtues, and others are well supplied by those we have chosen, and which we shall proceed to examine.

I. The name of castoreum is given to two bags, situated in the inguinal region of the male or female beaver, which contains a very odorous substance, soft and almost fluid when recently cut from the animal, but which dries, and assumes a resinous consistence, in process of time. This substance has an acrid, bitter, and nauseous taste; its smell is strong, aromatic, and even fetid; it consists of a coloured, resinous matter, soluble in spirit of wine or ether, together with a gelatinous mucilage, and an extractive part taken up by water, and a solid, which crystallizes in the aqueous solution by evaporation, but whose nature has not yet been examined. The resin of castoreum, in which its whole virtue resides, appears to be analogous to that of bile. All the substance of this animal product is inclosed in membranous cellules, which proceed from the internal tunic of the bag which contains them. The castoreum has not yet been accurately analyzed; it is only ascertained, that it affords a small quantity of essential oil and volatile alkali by distillation, and that the several matters of which it is composed

posed may be separated by means of ether, spirit of wine, and water.

It is medicinally used as a powerful antispasmodic in hysterical and hypochondriac affections, and the convulsions which are caused by those affections: it often produces the most speedy and happy effects, but it sometimes happens that it irritates instead of calming, according to the disposition of the nerves and sensible system; it must for this reason be administered at first only in small doses: it has likewise been successfully administered in the epilepsy and tetanus. The dose is from a few grains to half a drachm in substance; it enters into the composition of boles, and is often united, almost always advantageously, with opium, and the sedative or narcotic extracts; its spirituous and ethereal tinctures are likewise used, from a few drops to twenty-four or thirty-six grains, in proper liquids.

II. Musk is a substance, whose strong and permanent smell is universally known; it is contained in a bag placed near the umbilical region of a ruminating quadruped, resembling the antelope, from which it does not differ sufficiently to form a particular genus. This substance resembles castoreum in its chemical properties; it consists of a resin, united to a certain quantity of mucilage, bitter extract, and salt; it is often falsified; its virtues are

stronger

stronger than those of castoreum; and on account of its greater activity, it is used only in cases of imminent danger. It is prescribed as a powerful antispasmodic in convulsive disorders, the hydrophobia, &c.; and is likewise considered as a violent aphrodisiac. It must be used with great caution, because it often excites nervous affections, instead of mitigating them.

III. Hartshorn is an animal substance which is very frequently used in medicine; it is a bony substance, and does not in any respect differ from other bones; it contains abundance of tasteless jelly, very light, and nourishing, which is extracted by boiling the substance, reduced into small pieces, in eight or ten times its weight of water. When distilled in a retort, it affords a reddish and alkaline phlegm, called volatile spirit of hartshorn; an oil, more or less empyreumatic; and a large quantity of ammoniacal chalk, contaminated by a small quantity of oil; a prodigious quantity of gas is disengaged, for the most part inflammable. As the volatile salt is coloured, it is necessary to digest it in a small quantity of spirit of wine, which takes away the colouring oil. The carbonaceous residue being incinerated, is found to contain a small quantity of natrum, selenite, and much calcareous phosphat, mixed with phosphat of soda, which may be decomposed



posed by oil of vitriol, in the manner already described in treating of bones.

The spirit and the salt of hartshorn are used in medicine as good antispasmodics; the first, saturated with the acid salt of amber, forms the fluid called succinated spirit of hartshorn.

The oil of hartshorn, rectified by a gentle heat, becomes very white, odorous, volatile, and almost as inflammable as ether; it is known by the name of the animal oil of Dippel, a German chemist, who first prepared it. A great number of rectifications were formerly made to obtain this oil very white and fluid; but it has since been discovered, that two or three distillations are sufficient, provided care be taken, 1. To introduce the oil into the retort, by means of a long funnel, in order that the neck of this vessel may be very clean, as a single drop of the coloured oil is sufficient to give a tinge to all that comes over. 2. To take only the first most volatile and whitest portions. We are indebted to Messrs. Model and Baumé for these observations. Rouelle has likewise given a very good process for obtaining this oil: it consists in distilling it with water: and as there is only the most volatile and truly ethereal part contained in the oil of the first distillation, which is capable of rising at the degree of heat of boiling water, this method is attended with a certainty of the most attenuated and penetrating

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ing portion coming over alone. The animal oil of Dippel has a lively smell, and a singular degree of lightness and volatility, and exhibits all the properties of vegetable essential oils, and from which does not appear to differ, but in containing the volatile alkali, as appears by its converting syrup of violets to a green, according to the observation of M. Parmentier. This oil is used in drops, in nervous affections, the epilepsy, &c.

IV. The white substance, improperly called spermaceti, is an oily, concrete, crystalline, semi-transparent matter, taken out of the cavity of the cranium of the cachalot; it is purified by liquefaction, and the separation of another fluid and inconcrescible oil, with which it is mixed. This substance exhibits very singular chemical properties; for it resembles fat oils in some respects, and essential oils in others.

Spermaceti heated with the contact of air takes fire, and burns uniformly without emitting any disagreeable smell. It is therefore made into beautiful candles at Bayonne, at St. Jean de Luz, &c.

When distilled by a naked fire, it does not afford an acid phlegm like fat oils, as M. Thouvenel has observed, but it passes intirely, and almost without alteration, into the receiver, as soon as it begins to boil, and leaves a coaly mark in the retort. By repeating this operation,

operation, it loses its solid form, and remains fluid without becoming more volatile.

Spermaceti exposed to a hot air, becomes yellow and rancid, but less readily than the other concrete fat oils. The water in which it is boiled affords only a light mucilaginous unctuous residue.

The caustic alkali dissolves spermaceti, and forms a soap which gradually becomes solid, and even friable.

The nitrous and marine acids have no action on it. The concentrated vitriolic acid dissolves it, and alters its colour. This solution is precipitated by water, like the oil of camphor.

Spermaceti unites with sulphur like the fat oils.

The fat and essential oils dissolve spermaceti by the assistance of heat; hot spirit of wine likewise dissolves it, and suffers it to precipitate by cooling. Ether effects this solution in the cold, or by the simple heat of hand.

Has not spermaceti the same relation to fat oils, as camphor to essential oils?

This substance was formerly much used in medicine, a great number of virtues having been attributed to it; it was more particularly used in catarrhs, ulcers of the lungs, of the reins, &c. It is not at present used except as a softening remedy, and then in small doses, mixed with mucilages, because it is found

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to lie heavy on the stomach, occasioning nausea, and even vomiting.

I have found in animal matters, and particularly in the parenchyma of the liver, dried in the air for several years, and in the human muscles altered by putrefaction, a substance which possesses characters very similar to those of spermaceti.

V. The eggs of birds, and particularly those of poultry, are composed, 1. Of a bony shell, which contains a jelly, and calcareous phosphat, as M. Berniard has proved. 2. Of a membranous pellicle, placed beneath the shell, and which appears to be an expansion of fibrous matter. 3. Of a whitish fluid substance. 4. Of a yellow substance contained and suspended in the middle of the white; the germ is supported on this last substance.

White of egg is absolutely of the same nature as the serum of blood; it is viscid and adhesive, it converts the syrup of violets to a green, and contains cretaceous soda in a disengaged state; exposed to a gentle heat it coagulates into a white opaque mass, which emits an hepatic smell and gas. The white of egg coagulated and dried in a water-bath, affords an insipid phlegm, which putrefies, and itself becomes dry and of a reddish transparency resembling horn; by distillation in a retort, it affords ammoniacal chalk, and empyreumatic oil; its coal contains soda, and



and a small quantity of calcareous phosphat. M. Deyeux has likewise obtained a small quantity of sulphur by sublimation.

White of egg exposed to the air in fine stria, dries without putrefying, and forms a kind of transparent varnish. It is dissolved in water in all proportions; acids coagulate it, and if the coagulum diluted with water be filtered, the fluid which passes through affords by evaporation a neutral salt, consisting of the acid combined with soda: spirit of wine likewise coagulates the white of egg; lime-water precipitates calcareous phosphat, and the mercurial nitre precipitates phosphat of mercury, which by drying assumes a rose colour.

The yolk of egg is for the most part composed of an albuminous substance, which is mixed with a certain quantity of a mild oil, so that the mixture dissolves in water, and forms a kind of animal emulsion; if it be exposed to heat, it becomes less solid than the white; when dried, it undergoes a kind of softening, that arises from the disengagement of its oil, which exudes from its surface in this state; the oil may be obtained by pressure, and is found to be mild and insipid, and of a taste and smell slightly empyreumatic. The yolk of egg, after the oil has been thus extracted, affords the same products by distillation as all other animal matters. Acids and spirit of wine coagulate it;

it; the mild oil it contains exhibits a striking analogy between the eggs of animals and the seeds of vegetables, since these last likewise contain an oil which is in the same manner united with mucilage, and reduced to the emulsive state.

Eggs are of great use as food; the different parts are used in pharmacy and in medicine; the calcined shell is used as an absorbent; the oil of egg is softening, and is externally used in burns, chaps, &c.; yolk of egg renders oil soluble in water, and forms lochochs; it is triturated with resins, camphor, &c. The white of egg is successfully used in pharmacy and confectionary, to clarify the juices of plants, wheys, syrups, and other fluids; it is likewise applied on paintings, which it preserves by forming a transparent varnish on their surface.

VI. Ichthyocolla, or fish glue, is a substance partly gelatinous, and partly lymphatic, which is prepared by rolling up the membranes that form the air bladder of the sturgeon, and several other fishes, and is dried in the air, after it has been twisted into the form of a short cord as we receive it. This substance affords a viscid jelly by ebullition in water; by maceration for a certain time in that fluid, it may be unwrapped and extended into a kind of membrane. It is never brittle like the glass properly so called, but bends by virtue of its

fibrous elastic texture. A kind of glue is likewise prepared by boiling the skin of the stomach and intestines of fishes, but it has not the same properties as isinglass or fish-glue. Ichthyocolla affords all the products of other animal substances; it may be used in medicine as an emollient in disorders of the throat, intestines, &c.; but many other vegetable substances which possess the same virtue, are commonly preferred. It is used in the arts to clarify liquors, wine, coffee, &c.; it attracts and precipitates all the foreign substances which affect their transparency.

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## C H A P. XXIII.

Concerning the Product of Oviparous Quadrupeds, Serpents, Insects, and Worms, which are used in Medicine and the Arts.

**T**HE turtle, the frog, the lizard, and the viper, are used in medicine, decoctions or soups being made with their flesh and bones, to which peculiar virtues are attributed. It should seem, in fact, that the zoophagous animals, whose humours are more attenuated than most quadrupeds; whose parts

parts in general have a stronger smell, and appear to contain more saline matter, since they afford a large quantity of volatile alkali, when distilled by a gentle heat, after trituration with oil of tartar; it should seem, I say, that these animals must possess stronger and more numerous virtues. Many physicians, however, call their virtues in question, and class them with other animals. Notwithstanding this opinion, it is still customary to administer decoctions or soups of turtle and frogs in disorders attended with languor, consumptions without apparent cause, or any state of weakness which succeeds acute fevers; and it is often found that good effects follow. These decoctions appear to be more nourishing, lighter, and at the same time possessed of a certain activity, sufficiently indicated by their strong smell and peculiar taste. Green lizards have been greatly recommended for some years past, in disorders of the skin, cancers, &c.

Vipers are considered as the most active; the ancients spoke highly of their virtues in disorders of the skin, in those of the breast, and in chronical disorders, wherein the lymph is vitiated. We cannot avoid thinking that their decoctions must throw off the vicious matter through the pores of the skin, by virtue of their exalted spiritus rector; their powder, and their volatile salt has nearly the same virtues; they



are still administered in substance as food in the same disorders, and with success.

The chemical analysis of these animals by M. Thouvenel, afforded a jelly, more or less light, consistent, or viscid, an acute bitter and deliquescent extract, an albuminous concrescible substance, an ammoniacal salt, and an oily substance of a peculiar taste and smell, sometimes soluble in spirit of wine, &c.

II. Cantharides, a remedy of so great importance by its corrosive and epispastic quality, consist, according to M. Thouvenel, 1. Of a parenchyma, whose nature he has not determined, and which amounts to half the weight of these dried insects. 2. Of three drachms in the ounce, of a reddish, very bitter extractive substance, which affords an acid by distillation. 3. Of twelve grains per ounce of a yellow and wax-like matter, which produces the golden yellow colour of the cantharides; this substance when distilled, affords a very penetrating acid, and a concrete oil, resembling wax; water dissolves the extract, the yellow oil, and even a small quantity of the green oil; but ether attacks only this last, and may be successfully employed to separate it from the others. The virtue of the cantharides depends on this kind of green wax. To obtain the latter, at the same time with the extractive substance, and to form in  
general

general a tincture well charged with these insects, a mixture of equal parts of spirit of wine and water must be used, this mixed tincture being distilled affords a spirit of wine with a slight odour of cantharides, and the different substances, it held in solution, are separated, one after the other, in proportion as the evaporation goes forward.

III. The acid of ants was observed by Tragus, Bauhine, and several other botanists. We observe the flower of chicory to become very red in an ant heap. Samuel Fisher, Etmuller, and Hoffman, have successively made experiments on this acid. Margraaf carefully examined it, and found that ants contain a peculiar acid, fat oil, and an extract. Messrs. Arvidson and Oerne, have made the most complete series of experiments on this acid. The acid of ants are obtained more especially from the red ant, *formica rufa*, by distilling them in a retort, and by washing them in boiling water. This acid, when rectified, and rather concentrated, has a penetrating smell, and is corrosive; its taste is agreeable when greatly diluted with water, and it has thence been proposed to be used instead of vinegar; it quickly reddens all blue vegetable colours, is decomposed by fire, which converts it into the cretaceous acid, and by the vitriolic and nitrous acids which disengage the same cretaceous acid: it deprives the dephlogisticated

muriatic acid of the base of air, and is stronger than the vitriolic, boracic, cretaceous, acetic, and fuming nitrous acids. It forms a kind of ether with spirit of wine; the neutral salts it constitutes with alkaline bases have been examined by Messrs. Arvidson and Oerne. The formicate of pot-ash has been prepared by M. Thouvenel, by spreading linen impregnated with pot-ash on ant-hills uncovered; the ants running over the cloth emitted their acids, and odorant principle of the same nature, which they exhaled in so great an abundance, as to saturate the fixed alkali spread on the cloth. The lixivium of these linens afforded, by evaporation, a neutral salt crystallized in flat parallelograms, and prismatic columns which were not deliquescent.

Lime with this acid forms a crystallizable and soluble salt; in a word, the modern chemists consider the acid of ants as a peculiar acid, *sui generis*.

Spirit of wine, digested on ants, extracts a small quantity of essential oil, which with this fluid, forms the spirit of magnanimity of Hoffman. If these insects be boiled in water, and afterwards pressed, a fat oil is afforded, amounting to about thirteen drachms in the pound; this oil is of a greenish yellow, congeals at a much warmer temperature than oil of olives, and greatly resembles wax. The water of the decoction affords a reddish brown extract by evaporation, which has a fetid,

tid, acidulous, and caseous smell, with a bitter, nauseous, and acid taste. This extract is separated into two substances by the successive application of water and spirit of wine: the parenchyma of ants deprived of these different substances amounts to three ounces two drachms in the pound.

IV. The millipedes, acelli, porcelli, onisci, &c. presented certain peculiar circumstances in their analysis made by M. Thouvenel. By distillation on the water-bath without addition, they afford an insipid and alkaline phlegm, sometimes effervescing with acids, and converting the syrup of violets to a green: in this operation they lost five-eighths of their weight. By treatment with water and spirit of wine, they afterwards afforded two drachms of soluble matter, in the ounce; of which more than two-thirds were extractive matter, and the residue an oily or extractive substance. These two matters were easily separated by ether, which dissolves the latter without touching the extract; they differ from those of cantharides and ants, in affording more concrete volatile alkali, and no acid in their distillation. M. Thouvenel observes, on this subject, that among insects the millipedes appear to have the same relation to cantharides and ants, which reptiles have with respect to quadrupeds.

The neutral salts contained in these insects are very small in quantity, and very



difficult to be extracted. M. Thouvenel affirms, that the millipedes and earth-worms, lumbrici, constantly afforded him marine salt, with earthy bases, and base of vegetable alkali; while in ants, and cantharides, these two bases, the first of which always appeared to him the most abundant, are united with an acid, which has the character of the phosphoric acid. It is necessary to be observed here, that this chemist in his Dissertation, has not described either the methods of extracting these salts, nor the processes he made use of to ascertain their nature.

Cantharides and millipedes are only used in medicine; the latter appear to act as stimulants, and slight diuretics, and for this purpose they ought to be administered according to the experiments of M. Thouvenel, in a much more considerable dose than is usually prescribed. The expressed fluid of forty or fifty living millipedes given in a mild drink, or mixed with the juice of certain aperient plants, may be successfully prescribed in the jaundice, serous disorders, coagulations of the milk, &c. As to the cantharides, it is one of the most powerful medicines we are in possession of. M. Thouvenel tried on himself the effect of the green waxy matter, in which the virtue of these insects resides; when applied on the skin in the quantity of nine grains, it raised a blister full of serous matter, in the same manner as the

the powder of cantharides; but the most valuable observations resulting from his experiments on this powerful remedy, relate to the spirituous tincture of cantharides. He used it with the greatest success externally, in a dose of two drachms to two ounces and an half, in rheumatic and sciatic pains, and in the wandering gout; it heats the parts, accelerates the circulation, and excites evacuation by sweat, urine, and stool, according to the parts on which it is applied. He likewise relates certain good effects arising from this tincture internally administered by foreign physicians, but young practitioners ought to be advised that the internal use of this medicine should be very moderate, as it has been known to produce flushings on the skin, inflammations, sweating of blood, and pains in the loins and bladder, dysenteries, &c.

V. Honey and wax, prepared by bees, seem to belong to the vegetable kingdom, since these insects collect the first in the nectaria of the flowers, and the second in the antheræ of their stamina; nevertheless they have passed a peculiar elaboration, and besides, as they are obtained in consequence of the labour of bees, their properties ought to be examined in the history of insects.

Honey is a substance perfectly resembling saccharine juices, which we have treated of under vegetables. It has a white or yellowish

ish colour; a soft and grained consistence, a saccharine and aromatic smell; by means of spirit of wine, and even by water, with peculiar management, a true sugar is obtained; by distillation it affords an acid phlegm and an oil, and its coal is light and spongy like that of the mucilages of plants. The nitrous acid extracts an acid intirely similar to that of sugar; it is very soluble in water, with which it forms a syrup, and like sugar, passes to the spiritous fermentation; it is an excellent food, and a softening, and slightly aperient medicine; it is given dissolved in water, and mixed with vinegar, under the name of oximel. It is often combined with different acrid plants, as in the oxymel of squills, of colchicus; it is the vehicle in many medicines which bear its name, as the honey of roses, water-lilly, mercûrial honey, &c.

Wax is a concrete oily substance, similar to solid fat oil, such as the butter of cocoa, and still more resembling vegetable wax. Though it cannot be doubted that this substance is extracted from the stamina of flowers, it is nevertheless certain, that it receives a peculiar elaboration in the body of the animal; since, according to the trials of Reaumur, a flexible wax cannot be made with the powder of the antheræ. Wax which composes the honey-combs is yellow, and of an insipid taste; it is whitened by exposure to the

the action of dew, and of the air. After it has been reduced into thin pieces, the aerated muriatic acid whitens it very quickly; by a gentle heat it softens, melts, and forms a transparent oily fluid, which becomes solid and opake by cooling; when strongly heated with the contact of air, it takes fire as soon as it is volatilized; and this is the effect produced by the wick in candles. When distilled in a retort it affords an acid phlegm, of a strong and penetrating smell; an oil at first fluid, which afterwards fixes in the receiver, and has the consistence of butter; and leaves only a very small quantity of coal difficult to incinerate. Butter of wax being rectified a number of times, becomes fluid and volatile; wax does not alter by exposure to the air, except that it becomes coloured at the end of a certain time. It dissolves in oil, to which it gives consistence; when melted in these fluids in a mild heat, it forms medicaments, known by the name of cerates; spirit of wine does not act on wax; acids blacken it, alkalis combine with it, and convert it into soap.

Wax is used in a great number of arts; in pharmacy it is used in the preparations of pomatums, unguents, and plasters.

VI. Silk worms contain, especially when in the state of chrysalis, an acid liquor in the reservoir placed near the anus. M. Chauffier, of the Academy of Dijon, obtained



tained this acid by expressing the juice of the chrysalides in a cloth, and precipitating the mucilage by spirit of wine, and likewise by infusing the chrysalides in that liquor. This acid is very penetrating, of a yellow amber colour, but its nature and combinations are not yet known.

Many other insects likewise contain acids; the large caterpillar of the willow emits a liquor considerably acid, according to the remark of M. Bonnet. I have often observed the buprestes and staphylini give a red colour to the blue paper with which boxes were lined, wherein they were put. M. Chauffier has likewise obtained an acid from the grasshopper, the red bug, the lampyris, or shining worm.

Silk, which seems to be nothing but a kind of gummy matter dried, differs nevertheless from vegetable substances, 1. By the volatile alkali it affords in distillation. 2. By the mephitic obtained from it, by means of the nitrous acid. 3. By the peculiar oil which this acid separates in proportion as it converts it into saccharine acid, as M. Berthollet has shewn. It seems to be a compound of vegetable mucilage with a peculiar animal oil, which gives it flexibility, ductility, and elasticity.

VII. The improper name of gum lac is given to a resinous substance of a deep red, which is deposited on the branches of trees,

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by a kind of ant peculiar to the East-Indies. This substance appeared to Geoffroy to be a kind of nidus, in which the ants deposit their eggs. In fact, if stick-lac be broken, it is observed to be full of small cavities, or regular cellules, in which small oblong bodies are placed, which Geoffroy has considered as the embryos of ants. He thinks that the lac owes its colour to this animal substance; he regards the lac as a true wax, though its dryness, the aromatic odour it exhales in burning, and its solubility in spirit of wine, seem to indicate a resemblance between it and resins; by distillation it affords a kind of butter, according to the same author. It is distinguished in commerce into stick-lac, seed-lac, and shell-lac. It is used in the Levant to dye cloths and skins. It is the basis of sealing wax; a tincture is made with it, together with the spirit of cochlearia; it enters into the troches of amber, dentrifrice powders, and opiates, odorous pastills, &c.

VIII. Kermes, *Coccus infectorius*, was considered by the first naturalists as a tubercle and excrescent of plants. The more accurate observations of subsequent times have shewn, that it is the female of an insect arranged among hemiptera by Geoffroy; this female fixes itself among the leaves of the holm, where, after having been fecundated, it extends itself, dies, and soon loses the form of

of an insect; it has the appearance of a brown red cap, under which are inclosed a very great number of eggs. This cap was formerly used in dying, but has been neglected since the discovery of cochineal. Kermes exhibits the same chemical properties as this last substance; it enters into the confectio alkermes.

IX. Cochineal, like kermes, was long considered as a vegetable grain. Father Plumier is among the first who detected this error; it is, in fact, the female of an insect which differs from the kermes in the circumstance that it preserves its form, though fixed on the plants. The cochineal used in dying grows on the opuntia or Indian fig; it is collected in great quantities in South America. Geoffroy, who analyzed it, found it to contain the same principles as kermes; he obtained the volatile alkali from it. The form of this insect may be seen by macerating it in water. Cochineal is used to make carmine, and in dying it produces either a crimson or scarlet colour, according to the manner in which it is used. As it is an extractive colouring matter, it cannot be applied in substances intended to be dyed, but by the help of a corrosive. It readily adheres to wool, and tinges it of a scarlet colour, by means of the solution of tin in aqua regia, which decomposes the colouring extract, and singularly enlivens the tinge.

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The method of giving this beautiful colour to silk was not known before the time of Macquer; this celebrated chemist discovered that silk may be dyed, if previously impregnated with the solution of tin, before it is plunged in the bath of cochineal, instead of mixing the solution in the bath, as is done with wool.

X. The strong concretions falsely called crabs eyes, lapides cancrorum, are found in the number of two in the internal and interior parts of the stomach of these insects; they are round, convex on one side, concave on the other, and placed in the animal between the two membranes of the ventricle. As they are not found, but at the time in which the crabs change their covering and their stomach; and as they disappear gradually in proportion as the new covering becomes hard, it is thought, with great probability, that they serve to re-produce the calcareous substance, which constitutes the basis of their shells.

These stones have no taste; they contain a small quantity of gelatinous matter; they are prepared by repeated washing and grinding on a stone with a small quantity of water to reduce them into a soft paste, which is moulded into lozenges and dried; the water carrying off the animal jelly contained in these stones; the residue is mere earthy matter. When prepared in this manner, they make



make a strong effervescence with all acids, and are absolutely of the same nature as chalk; they have, therefore, no other virtue than that of absorbing acidities in the first passages; and the opinions in consequence of which animal substances in general have been placed in the rank of aperient, diuretic, and even cordial remedies, are very far from being well founded.

XI. The same observation likewise applies to coral, which is a calcareous white earth, or rose-coloured ramification, forming the basis of the habitation of the sea polypi. Preparations of these are made in the same manner as from crabs eyes, and it is of the same calcareous nature as that substance; it enters into the confectio alkermes, pulvis gutteti, amber troches, &c. Numberless virtues have been attributed to it, but it possesses no other than that of a mere absorbent, unless it be combined with acids; this, as well as crabs eyes, is often in the state of a neutral salt, combined with vinegar or lemon juice, as an aperient diuretic, &c.

XII. The coralline, called sea-moss, is, as we have observed, a peculiar habitation of polypi. It affords the same principles in the retort as animal substances, and has a salt, bitter, and disagreeable taste; it is successfully used as a vermifuge, with which intention it is prescribed in powder,

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in the dose of twenty-four grains for infants, to that of two drachms or more for adults. It is made into an anthelmintic syrup, and enters into vermifuge powders. This common coralline must not be confounded with the substance at present called coralline of Corsica, or helminto-corton: this last is a vegetable, a kind of fucus, which has the property of forming a jelly with hot water.

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## C H A P. XXIV.

Concerning the Putrefaction of Animal Substances.

**T**HOUGH vegetable substances are susceptible of decomposition, and intire destruction, by the putrid fermentation, they are nevertheless in general far from being as capable of entering into this state of intestine motion as animal matters; the putrefaction of these last is much more rapid and its phenomena are different: all the fluids and soft parts of animals are alike capable of undergoing this process, while many vegetable matters seem exempted from it, or at least are not changed by it but slowly, and with great difficulty.

The putrefaction of animals, which we cannot but consider, with Boerhaave, as a

true fermentation, is one of the most important, and at the same time the most difficult to be known; all the labours of the philosophical world, since the time of Lord Chancellor Bacon, who was well aware of the importance of inquiries into this subject, have served only to clear up a few circumstances, and to exhibit the general phenomena of putrefying substances. Beccher, Hales, Stahl, Pringle, Macbride, Geber, Baumé, the valuable author of the *Essays on Putrefaction*, and those of the *Dissertations on Antiseptics*, which were crowned in 1767 by the Academy of Dijon, have observed, and carefully described the facts which accompany the putrid change in bodies: but we shall see, in the following pages, that a great number of experiments remains to be made, before we can esteem ourselves acquainted with the whole of the phenomena of this natural operation.

Every fluid or soft animal substance, exposed to a moderate temperature, of sixty-five degrees or more, passes with more or less rapidity through the following changes. Its colour becomes paler, and its consistence diminishes; if it be a solid part, such as flesh, it softens, and a serous matter sweats out, whose colour quickly changes; its texture becomes relaxed, and its organization destroyed; its smell becomes faint, and disagreeable; the substance gradually sinks down,

down, and is diminished in bulk ; its smell becomes stronger, and alkaline. If the subject be contained in a close vessel, the progress of putrefaction, at this stage, seems to slacken ; no other smell but that of a pungent alkali is perceived ; the matter effervesces with acids, and converts syrup of violets to a green. But if the communication with the air be admitted, the urinous exhalation is dissipated, and a peculiar putrid smell is spread around, with a kind of impetuosity ;—a smell of the most insupportable kind, which lasts a long time, and pervades every place, affecting the bodies of living animals, after the manner of a ferment, capable of altering the fluids : this smell is corrected, and as it were confined by the volatile alkali. When the latter is volatilized, the putrefactive process becomes active a second time, and the substance suddenly swells up, becomes filled with bubbles of air, and soon after subsides again. Its colour changes, the fibrous texture of the flesh being then scarcely distinguishable ; and the whole is changed into a soft, brown, or greenish matter, of the consistence of a poultice, whose smell is faint, nauseous, and very active on the bodies of animals. The odorant principle gradually loses its force ; the fluid portion of the flesh assumes a kind of consistence, its colour becomes deeper, and it is finally re-



duced into a friable matter, rather deliquescent, which being rubbed between the fingers, breaks into a coarse powder, like earth. This is the last state observed in the putrefaction of animal substances; they do not arrive at this term but at the end of a considerable time. Eighteen months, two, and even three years, are scarcely sufficient for the destruction of the whole body of animals exposed to the air; and the time necessary for the total destruction of bodies buried in the earth has not yet been estimated. Not to mention bodies which in certain soils are dried, and remain unchangeable; many facts prove, that human bodies, buried in great numbers in a moist soil, are not destroyed even at the end of thirty years.

From this outline it follows, 1. That the conditions proper to develop and maintain the putrefaction of animal substances, are the contact of air, heat, moisture, and repose. 2. That the volatile alkali is the product of putrefaction, formed during that process, since it did not exist as such in the animal substances before the commencement of that intestine motion. 3. That putrefaction, effected by the intestine motion, proper to organized matters, may be compared to the action of fire, as Mr. Goddard has remarked, and may be considered as spontaneous decomposition, as M. Baumé thinks, from  
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which it differs only in its slowness. 4. That in this natural operation, the proximate principles of animals re-act on each other, by the assistance of water and of heat, by means of which the motion commenced; that the volatile matters thus formed, become gradually dissipated in the order of their volatility, and that nothing remains after the putrefaction, but an insipid, and as it were earthy substance. 5, and lastly, That the putrid exhalation, which is so well distinguished by the nerves of smell, and whose action is so powerful on the animal economy, may be considered as one of the principal products of putrefaction, as it is peculiar to this operation, and is not observed in any other natural phenomena; and because it appears capable of developing the putrefactive motion in all the animal substances which are exposed to its action. As to the nature of this fugacious odorant substance, we must observe, that it is more particularly with respect to this that inquiries are very little advanced, though they highly deserve to be followed. We only know, that it is extremely volatile, attenuated, and penetrating; that pure air, water in large quantities, and acid gases, are capable of moderating its effects. Though it ought not to be confounded with the cretaceous acid, or fixed air, which is disengaged in large quantities

from putrefying bodies, and to whose disengagement Macbride intirely attributed the cause of this natural phenomenon; and though we are by no means warranted in comparing it, either to the inflammable gas disengaged from putrescent bodies, nor with the luminous matter, which shines at the surface of putrid animal fibres, converting them into a kind of phosphorus; yet it must be allowed, that these substances have very evident relations with each other, since it always accompanies them, is equally volatile and attenuating, and acts with equal energy on the organs of animals. Four degrees or stages of the putrid or fermentation may be distinguished, according to M. Boissieu.

The first, which this physician calls a tendency to putrefaction, consists in an alteration, not considerable, which appears by a faint or slight smell, and a softening of the substance.

The second degree, or commencement of putrefaction, is sometimes indicated by marks of acidity: the substances which undergo this, lose weight, become fetid and soft, and a serous matter exudes, if they be in close vessels; or they become dry, and of a dark colour, if exposed to the air.

In the third degree, or advanced stage of putrefaction, the putrescent matters emit an alkaline smell, mixed with the putrid and  
nauseous

nauseous smell; they fall into dissolution, their colour changes more and more, and they lose at the same time both weight and bulk.

Lastly, the fourth degree, or that of complete putrefaction, is known by the volatile alkali being intirely and completely dissipated; the fetid smell loses its force, the volume and weight of the putrefied substance are considerably diminished, a gelatinous mucus is separated, they dry by degrees, and are at length reduced to a friable and earthy matter.

Such are the general phenomena observed in the putrefaction of animal substances, but they are far from being the same in all matters which putrefy. There is a great difference between the putrefaction of the parts of living animals, and that of their dead organs. The motion which exists in the former, singularly modifies the phenomena of this alteration; and physicians have frequent opportunities of observing the difference between these two states, with respect to putrefaction. Besides this, every humour, and every solid part, separated from a dead animal, has likewise its peculiar manner of putrefying. The muscular, membranous, or parenchymatous texture of the organs; the oily, mucilaginous, or lymphatic nature of the humours, their consistence, their state with respect to



that of the animal which afforded them, greatly influence the putrefactive motion, and modify it in a thousand manners, perhaps impossible to be estimated. And how greatly will the difficulty of the subject be increased, if we add to this enumeration, the state of the air, its temperature, elasticity, weight, dryness, or moisture; the exposition of the putrefying substance in various places, and even the form of the vessels which contain it; all these circumstances being capable of varying the phenomena? It must therefore be allowed, that the history of animal putrefaction is scarcely begun, and that it demands an immense series of inquiries and experiments.

The phenomena hitherto observed shew, that water is the cause of putrefaction; it is most probable that this fluid is decomposed, that its oxygenous principle seizes the mephitic of the animal substances, and contributes to the formation of the nitrous acid, so frequently found in animal matters; and that the inflammable gas of the water, united to a portion of the same mephitic, which abounds in these substances, produces the volatile alkali that flies off. The oily principle is preserved for the longest time; the calcareous phosphat, and the phosphat of soda, united to a portion of the carbonaceous principle, and perhaps with a small quantity

tity of the fat matter, seem to constitute the apparently earthy residue of putrefied animal matters.

These general data are sufficient to shew, that putrefaction separates and volatilizes the principles of animal matters; that nature reduces them, by the slow decomposition of dead animals, to the most simple substances, destined to enter into new combinations; and that it is in this manner that the purposes of the general system are accomplished, by the continual change of the form and nature of bodies, which pass without intermission from one kingdom to another.

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# I N D E X.

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**DIRECTIONS TO THE BINDER.**

The Tables to this Work, from I. to VIII. are to be placed at the End of this Volume, after the Index.

Table I.

*The Division and Characters of the Eight Classes of Animals, by DAUBENTON.*

A N I M A L S.

# A N I M A L S.

| Having an Head.                            |                                  |                                                    |                                     | The most Part having no Head.                  |                       |                        |                                 |
|--------------------------------------------|----------------------------------|----------------------------------------------------|-------------------------------------|------------------------------------------------|-----------------------|------------------------|---------------------------------|
| With Noftrils.                             |                                  |                                                    |                                     | Without Noftrils.                              |                       |                        |                                 |
| With Ears.                                 |                                  |                                                    |                                     | Without Ears.                                  |                       |                        |                                 |
| Two Ventricles in the Heart.               |                                  | One Ventricle in the Heart.                        |                                     | The Heart variously formed, or unknown.        |                       |                        |                                 |
| Warm Blood.                                |                                  | Blood nearly cold.                                 |                                     | A whitish Fluid, instead of Blood.             |                       |                        |                                 |
| Inspiring and expiring the Air frequently. |                                  | Inspiring and expiring the Air, at long Intervals. |                                     | Admitting the Air by Spiracula.                |                       |                        |                                 |
|                                            |                                  |                                                    |                                     | No apparent Entrance or Aperture to admit Air. |                       |                        |                                 |
| Viviparous.                                |                                  | Oviparous.                                         |                                     |                                                |                       |                        |                                 |
| With Teats.                                |                                  | Without Teats.                                     |                                     |                                                |                       |                        |                                 |
| 1st Order.<br>QUADRUPEDS.                  | 2d Order.<br>CRETACEOUS ANIMALS. | 3d Order.<br>BIRDS.                                | 4th Order.<br>OVIPAROUS QUADRUPEDS. | 5th Order.<br>SERPENTS.                        | 6th Order.<br>FISHES. | 7th Order.<br>INSECTS. | 8th Order.<br>WORMS.            |
| Four Feet and hairy Skin.                  | Fins and no Hair.                | Feathered.                                         | Four Feet and no Hair.              | Scaly, without Feet or Fins.                   | Scaly, with Fins.     | Having Antennæ.        | Having neither Feet nor Scales. |



Table II.

*Quadrupeds, divided according to*

|             |                                                              | ORDERS. |        | S                                                                     |
|-------------|--------------------------------------------------------------|---------|--------|-----------------------------------------------------------------------|
| QUADRUPEDS, | Without teeth                                                | —       | I.     | —                                                                     |
|             | With grinders only                                           | —       | II.    | —                                                                     |
|             | Grinders and canine teeth only                               | —       | III.   | —                                                                     |
|             | Incisive teeth in the lower jaw only.                        | {       | IV.    | Ruminant, ung                                                         |
|             |                                                              |         | V.     | { Ruminant, with<br>cloven feet; eight<br>incisive teeth. { Sim<br>ho |
|             | Ungulated feet                                               | {       | VI.    | The hoof entire.                                                      |
|             |                                                              |         | VII.   | The Hoof cloven                                                       |
|             |                                                              |         | VIII.  | Three ungulated toes on ea                                            |
|             |                                                              |         | IX.    | { Four ungulated toes befor                                           |
|             |                                                              |         | X.     |                                                                       |
|             |                                                              |         | XI.    | Four ungulated toes on eac                                            |
|             | Ungulated feet,<br>and two incisive<br>teeth in each<br>jaw. | {       | XII.   | { Without canine teeth { S                                            |
|             |                                                              |         |        | { With canine teeth {                                                 |
|             | Incisive teeth in<br>both jaws.                              | {       | XIII.  | —                                                                     |
|             |                                                              |         | XIV.   | —                                                                     |
|             |                                                              |         | XV.    | —                                                                     |
|             |                                                              |         | XVI.   | { The toes separate from<br>each other.                               |
|             |                                                              |         |        |                                                                       |
|             |                                                              | {       | XVII.  | { The toes joined together                                            |
|             |                                                              |         |        |                                                                       |
|             |                                                              | {       | XVIII. | {                                                                     |
|             |                                                              |         |        |                                                                       |

# S E C T I O N S.

GENERA.

|                                   |                                                              |                                                 |              |  |                          |                      |
|-----------------------------------|--------------------------------------------------------------|-------------------------------------------------|--------------|--|--------------------------|----------------------|
|                                   | { Hairy skin                                                 |                                                 |              |  | Ant-eater . . . . .      | <i>Mymecophaga.</i>  |
|                                   | { Scaly                                                      |                                                 |              |  | Manis . . . . .          | <i>Pholidotus.</i>   |
|                                   | { Hairy skin                                                 |                                                 |              |  | Sloth . . . . .          | <i>Tardigradus.</i>  |
|                                   | { Bony covering or shell                                     |                                                 |              |  | Armadillo . . . . .      | <i>Catapbractus.</i> |
|                                   | { Two long tusks and a trunk                                 |                                                 |              |  | Elephant . . . . .       | <i>Elephas.</i>      |
|                                   | { Two long tusks, no trunk                                   |                                                 |              |  | Sea Cow . . . . .        | <i>Odobenus.</i>     |
| at, ungulated; six incisive teeth |                                                              |                                                 |              |  | Camel . . . . .          | <i>Camelus.</i>      |
| { Simple horns.                   | { Turned upwards.                                            | { Fore legs longer than hinder legs             |              |  | Camelopardalis . . . . . | <i>Giraffa.</i>      |
|                                   | { Turned back                                                | { The legs of equal lengths                     |              |  | Goat . . . . .           | <i>Hircus.</i>       |
|                                   | { Turned sideways                                            |                                                 |              |  | Sheep . . . . .          | <i>Aries.</i>        |
|                                   | { Branched horns                                             |                                                 |              |  | Ox . . . . .             | <i>Bos.</i>          |
| No horns                          |                                                              |                                                 |              |  | Stag . . . . .           | <i>Cervus.</i>       |
|                                   |                                                              |                                                 |              |  | Musk . . . . .           | <i>Tragul.</i>       |
|                                   |                                                              |                                                 |              |  | Horse . . . . .          | <i>Equus.</i>        |
|                                   |                                                              |                                                 |              |  | Hog . . . . .            | <i>Sus.</i>          |
| es on each foot,                  |                                                              |                                                 |              |  | Rhinoceros . . . . .     | <i>Rhinoceros.</i>   |
| es before, three behind,          | { Two incisive teeth in each jaw,                            |                                                 |              |  | River Hog . . . . .      | <i>Hydrochærus.</i>  |
| es on each foot                   | { Ten incisive teeth in each jaw,                            |                                                 |              |  | Tapir . . . . .          | <i>Tapirus.</i>      |
| { Teeth                           | { Spines on the body                                         |                                                 |              |  | River Horse . . . . .    | <i>Hippopotamus.</i> |
|                                   | { Without spines.                                            | { Tail flat and scaly                           |              |  | Porcupine . . . . .      | <i>Hyrix.</i>        |
|                                   |                                                              | { Short tail { Long ears                        |              |  | Beaver . . . . .         | <i>Castor.</i>       |
|                                   |                                                              |                                                 | { Short ears |  | Hare . . . . .           | <i>Lepus.</i>        |
|                                   |                                                              | { Long tail, { Flat                             |              |  | Coney . . . . .          | <i>Cuniculus.</i>    |
|                                   |                                                              |                                                 | { Round      |  | Squirrel . . . . .       | <i>Sciurus.</i>      |
|                                   |                                                              | { Naked tail                                    |              |  | Dormouse . . . . .       | <i>Glis.</i>         |
|                                   |                                                              | { Without spines on the body                    |              |  | Rat . . . . .            | <i>Mus.</i>          |
|                                   |                                                              | { With spines                                   |              |  | Shrew Mouse . . . . .    | <i>Musaraneus.</i>   |
|                                   |                                                              | { Separate toes                                 |              |  | Hedge Hog . . . . .      | <i>Erinaceus.</i>    |
|                                   |                                                              | { Toes joined by a membrane so as to form wings |              |  | Monkey . . . . .         | <i>Sincia.</i>       |
|                                   |                                                              |                                                 |              |  |                          | <i>Pteropus.</i>     |
|                                   |                                                              | { Separate toes                                 |              |  | Maucauco . . . . .       | <i>Prosimia.</i>     |
|                                   |                                                              | { The fore toe joined so as to form wings       |              |  | Bat . . . . .            | <i>Vespertilio.</i>  |
|                                   |                                                              |                                                 |              |  | Seal . . . . .           | <i>Phoca.</i>        |
| { rate from er.                   | { Four toes on the fore, and five on the hinder feet         |                                                 |              |  | Hyæna . . . . .          | <i>Hyæna.</i>        |
|                                   | { Five toes on the fore, and four on the hinder feet         |                                                 |              |  | Dog . . . . .            | <i>Canis.</i>        |
|                                   | { Five toes on each foot, { First toe remote from the other, |                                                 |              |  | Weazel . . . . .         | <i>Mustela.</i>      |
|                                   |                                                              | { First toe near the other                      |              |  | Badger . . . . .         | <i>Meles.</i>        |
|                                   | { Feet which rest on the heel in walking                     |                                                 |              |  | Bear . . . . .           | <i>Ursus.</i>        |
|                                   | { Hooked claws which may be drawn back and concealed         |                                                 |              |  | Cat . . . . .            | <i>Felis.</i>        |
| d together by a membrane          |                                                              |                                                 |              |  | Otter . . . . .          | <i>Lutra.</i>        |
|                                   |                                                              |                                                 |              |  | Mole . . . . .           | <i>Talpa.</i>        |
|                                   |                                                              |                                                 |              |  | Opossum . . . . .        | <i>Philander.</i>    |



BIRDS  
ARE

Either  
CLOVEN-FOOTED  
that is, they have  
the toes naked,  
and apart from  
each other.

The legs fea-  
thered as low  
as the calcane-  
um, or bone  
which sustains  
the toes.

Four toes all  
separate from  
each other,  
quite to their  
base.

Three toes before and one behind. — — —

Two toes before and two behind — — —

The middle toe united with the exterior, for the space of three phalan-  
ges, and with the interior for the space of one phalanx; four toes; }  
three before, one behind.

Wings too small for flight — — — — —

The lower  
part of the legs  
without fea-  
thers.

Wings large  
enough for  
flight.

Three toes only, all before. — — — —

Three toes before, and one behind. — — —

The membranes of the feet divided. Four toes; three before and one behind, which  
are divided, and have membranous edges.

The membranes partly divided; the toes joined together near their base; the legs  
placed behind near the anus.

or  
WEB-FOOTED;  
that is, they have  
the toes furnished  
with membranes.

The membra-  
nes entire.

The legs placed  
behind near the  
anus.

The legs placed  
in the middle of  
the body, and  
shorter than it.

Three toes before, connected by a membrane; no  
toe behind.

Three toes before, connected by a membrane; one  
separate toe behind.

Without a posterior toe. — — —

The three ante-  
rior toes con-  
nected by a  
membrane.

A fourth toe  
behind, se-  
parate from  
the others.

Indented beak — XX

Beak not indented XX

The four toes connected by a membrane — — XX

The legs longer than the body. — — — — — XX

I.

II.

III.

IV.

V.

VI.

VII.

VIII.

IX.

X.

XI.

XII.

XIII.

XIV.

XV.

XVI.

XVII.

XVIII.

XIX.

XX.

XXI.

XXII.

XXIII.

XXIV.

XXV.



| ORDERS. |                                                                                                                                                                       | SECTIONS.                                                                                                                                            |                                         | GENERA.          |                  |
|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------|------------------|------------------|
| I.      | The beak strait; the upper mandible thickened, and somewhat curved at the point; the nostrils half covered with a thick soft membrane. It consists of one genus only. |                                                                                                                                                      |                                         | Pigeon           | - Columba.       |
| II.     | The beak conical and curved. It consists of six genera.                                                                                                               | Sections.                                                                                                                                            | 1. The head ornamented with appendices. | Turkey           | - Gallo Pavo.    |
|         |                                                                                                                                                                       |                                                                                                                                                      |                                         | Cock and Hen     | - Gallus.        |
|         |                                                                                                                                                                       |                                                                                                                                                      |                                         | Guinea Hen       | - Meleagris.     |
|         |                                                                                                                                                                       |                                                                                                                                                      |                                         | Grouse           | - Lagopus.       |
|         |                                                                                                                                                                       |                                                                                                                                                      |                                         | Partridge        | - Perdix.        |
|         |                                                                                                                                                                       |                                                                                                                                                      |                                         | Pheasant         | - Phasianus.     |
|         |                                                                                                                                                                       |                                                                                                                                                      |                                         | Hawk             | - Accipiter.     |
|         |                                                                                                                                                                       |                                                                                                                                                      |                                         | Eagle            | - Aquila.        |
|         |                                                                                                                                                                       |                                                                                                                                                      |                                         | Vulture          | - Vultur.        |
| III.    | The beak short and crooked. It consists of five genera.                                                                                                               | 1. The base of the beak covered with a naked skin.                                                                                                   |                                         | Owl              | - Strix.         |
|         |                                                                                                                                                                       | 2. The base of the beak covered with feathers turned forwards.                                                                                       |                                         | Chough           | - Coracia.       |
|         |                                                                                                                                                                       |                                                                                                                                                      |                                         | Crow             | - Corvus.        |
|         |                                                                                                                                                                       |                                                                                                                                                      |                                         | Magpie           | - Pica.          |
|         |                                                                                                                                                                       |                                                                                                                                                      |                                         | Roller           | - Galgulus.      |
|         |                                                                                                                                                                       |                                                                                                                                                      |                                         | Oriole           | - Icterus.       |
|         |                                                                                                                                                                       |                                                                                                                                                      |                                         | Bird of Paradise | - Manucodiata.   |
| IV.     | The beak long and conical. It consists of six genera.                                                                                                                 | 1. The feathers on the base of the beak turned forward, and covering the nostrils.                                                                   |                                         | Butcher Bird     | - Lanius.        |
|         |                                                                                                                                                                       | 2. The feathers at the base of the beak turned backward; the nostrils uncovered.                                                                     |                                         | Thrush           | - Turdus.        |
|         |                                                                                                                                                                       |                                                                                                                                                      |                                         | Chatterer        | - Cotinga.       |
|         |                                                                                                                                                                       |                                                                                                                                                      |                                         | Fly catcher      | - Muscicapa.     |
| V.      | The beak strait; the upper mandible grooved on each side towards the point. It consists of four genera.                                                               | 1. The beak convex above.                                                                                                                            |                                         | Beef-eater       | - Buphagus.      |
|         |                                                                                                                                                                       | 2. The beak flattened horizontally towards the base, and nearly triangular.                                                                          |                                         | Starling         | - Sturnus.       |
| VI.     | The beak strait, and the mandibles not grooved. It consists of two genera.                                                                                            |                                                                                                                                                      |                                         | Hoopoe           | - Upupa.         |
| VII.    | The beak slender and rather bent. It consists of two genera.                                                                                                          |                                                                                                                                                      |                                         | Promerops        | - Promerops.     |
| VIII.   | The beak very small, flattened horizontally at its base, and bent at the point; the opening of the mouth appears larger than the head. It consists of two genera.     |                                                                                                                                                      |                                         | Goat-sucker      | - Caprimulgus.   |
|         |                                                                                                                                                                       |                                                                                                                                                      |                                         | Swallow          | - Hirundo.       |
| IX.     | The beak conical, and gradually diminishing to the point. It consists of eight genera.                                                                                | 1. The two mandibles strait.                                                                                                                         |                                         | Tanager          | - Tangara.       |
|         |                                                                                                                                                                       |                                                                                                                                                      |                                         | Goldfinch        | - Carduelis.     |
|         |                                                                                                                                                                       |                                                                                                                                                      |                                         | Sparrow          | - Passer.        |
|         |                                                                                                                                                                       |                                                                                                                                                      |                                         | Grosbeak         | - Coccyzus.      |
|         |                                                                                                                                                                       |                                                                                                                                                      |                                         | Bunting          | - Emberiza.      |
|         |                                                                                                                                                                       |                                                                                                                                                      |                                         | Colly            | - Colinus.       |
|         |                                                                                                                                                                       |                                                                                                                                                      |                                         | Bulfinch         | - Pyrrhula.      |
|         |                                                                                                                                                                       |                                                                                                                                                      |                                         | Crossbill        | - Loxia.         |
|         |                                                                                                                                                                       |                                                                                                                                                      |                                         | Lark             | - Alauda.        |
|         |                                                                                                                                                                       |                                                                                                                                                      |                                         | Beccafico        | - Ficedula.      |
|         |                                                                                                                                                                       |                                                                                                                                                      |                                         | Tit-mouse        | - Parus.         |
| X.      | The beak awl-shaped. It consists of three genera.                                                                                                                     | 1. The nostrils uncovered.                                                                                                                           |                                         | Nuthatch         | - Sitta.         |
|         |                                                                                                                                                                       | 2. The nostrils covered by the feathers at the base of the beak.                                                                                     |                                         |                  |                  |
| XI.     | The beak wedge-shaped. It consists of one genus only.                                                                                                                 |                                                                                                                                                      |                                         |                  |                  |
| XII.    | The beak filiform. It consists of three genera.                                                                                                                       | 1. The beak curved.                                                                                                                                  |                                         | Creepers         | - Certhia.       |
|         |                                                                                                                                                                       | 2. The beak flattened horizontally, and a little enlarged at the point; the feet very short.                                                         |                                         | Humming Bird     | - Polytmus.      |
|         |                                                                                                                                                                       |                                                                                                                                                      |                                         |                  | - Mellisuga.     |
|         |                                                                                                                                                                       | 1. The tongue very long and vermiform, but not longer than the beak.                                                                                 |                                         | Wryneck          | - Torquilla.     |
|         |                                                                                                                                                                       | 2. The beak very long, quadrangular, and pointed.                                                                                                    |                                         | Wood-pecker      | - Picus.         |
|         |                                                                                                                                                                       | 3. The beak somewhat curved, convex at its upper part, and flattened laterally.                                                                      |                                         | Jacamar          | - Galbula.       |
|         |                                                                                                                                                                       |                                                                                                                                                      |                                         | Barbet           | - Bucco.         |
|         |                                                                                                                                                                       |                                                                                                                                                      |                                         | Cuckoo           | - Cuculus.       |
|         |                                                                                                                                                                       |                                                                                                                                                      |                                         | Curucui          | - Trogon.        |
|         |                                                                                                                                                                       |                                                                                                                                                      |                                         | Ani              | - Crotophaga.    |
|         |                                                                                                                                                                       |                                                                                                                                                      |                                         | Parrot           | - Psittacus.     |
| XIII.   | Consisting of nine genera.                                                                                                                                            | 4. The beak short and crooked                                                                                                                        |                                         | Toucan           | - Tucana.        |
|         |                                                                                                                                                                       | 5. The beak long, and as thick as the head, indented like a saw; the point of each mandible turned downwards.                                        |                                         |                  |                  |
|         |                                                                                                                                                                       | 1. The beak short and flattened laterally near the point.                                                                                            |                                         | Manakin          | - Rupicola.      |
|         |                                                                                                                                                                       | 2. The beak conical and indented like a saw; the end of each mandible bent downwards.                                                                |                                         | Motmot           | - Momotus.       |
|         |                                                                                                                                                                       | 3. The beak strait and of a moderate length.                                                                                                         |                                         | King's-fisher    | - Ispida.        |
|         |                                                                                                                                                                       | 4. The beak curved and sharp.                                                                                                                        |                                         | Tody             | - Todus.         |
|         |                                                                                                                                                                       | 5. The beak thick and formed like a scythe.                                                                                                          |                                         | Bee-eater        | - Apisiter.      |
|         |                                                                                                                                                                       |                                                                                                                                                      |                                         | Hornbill         | - Hydrocorax.    |
|         |                                                                                                                                                                       | 1. Two toes before, none behind; the beak strait, somewhat flattened horizontally, and curved at the point; the upper part of the head bald & scaly. |                                         | Ostrich          | - Struthio.      |
|         |                                                                                                                                                                       | 2. Three toes before, none behind,                                                                                                                   |                                         | Cassary          | - Rhea.          |
|         |                                                                                                                                                                       | 3. Three toes before, one behind; the beak long and strong; both mandibles hooked at the point.                                                      |                                         | Dodo             | - Raphus.        |
| XV.     | four genera                                                                                                                                                           | 1. The beak conical and curved.                                                                                                                      |                                         | Bustard          | - Otis.          |
|         |                                                                                                                                                                       | 2. The beak strait and thickest at the point.                                                                                                        |                                         | Long-Legs        | - Himantopus.    |
|         |                                                                                                                                                                       |                                                                                                                                                      |                                         | Oyster-catcher   | - Ostralega.     |
|         |                                                                                                                                                                       |                                                                                                                                                      |                                         | Plover           | - Pluvialis.     |
|         |                                                                                                                                                                       |                                                                                                                                                      |                                         | Lapwing          | - Vanellus.      |
|         |                                                                                                                                                                       |                                                                                                                                                      |                                         | Jacana           | - Jacana.        |
|         |                                                                                                                                                                       | 1. The beak strait and thickest near the point.                                                                                                      |                                         | Turnstone        | - Arenaria.      |
|         |                                                                                                                                                                       | 2. The beak a little turned up, and somewhat flattened horizontally.                                                                                 |                                         | Pratincole       | - Glareola.      |
|         |                                                                                                                                                                       | 3. The beak convex above, and flattened laterally                                                                                                    |                                         | Rail             | - Rallus.        |
|         |                                                                                                                                                                       | 4. The beak strait and flattened laterally.                                                                                                          |                                         | Sandpiper        | - Tringa.        |
|         |                                                                                                                                                                       |                                                                                                                                                      |                                         | Godwit           | - Limosa.        |
|         |                                                                                                                                                                       |                                                                                                                                                      |                                         | Woodcock         | - Scolopax.      |
|         |                                                                                                                                                                       |                                                                                                                                                      |                                         | Curlew           | - Numenius.      |
|         |                                                                                                                                                                       | 6. The beak curved in an arc downwards.                                                                                                              |                                         | Spoonbill        | - Plataea.       |
|         |                                                                                                                                                                       | 7. The beak strait, flattened horizontally, and dilated at its extremity like a spatula.                                                             |                                         | Stork            | - Ciconia.       |
|         |                                                                                                                                                                       |                                                                                                                                                      |                                         | Heron            | - Ardea.         |
|         |                                                                                                                                                                       |                                                                                                                                                      |                                         | Umbre            | - Scopus.        |
|         |                                                                                                                                                                       | 8. The beak long and thick.                                                                                                                          |                                         | Boat-bill        | - Cochlearius.   |
|         |                                                                                                                                                                       | 9. The beak short and thick, the upper mandible in the form of a spoon.                                                                              |                                         |                  |                  |
|         |                                                                                                                                                                       | 10. The beak short and strait, conical at the point; the head adorned with a crown of feathers.                                                      |                                         | Crown Bird       | - Balaerica.     |
|         |                                                                                                                                                                       | 11. The beak conical and curved.                                                                                                                     |                                         | Cariama          | - Cariama.       |
|         |                                                                                                                                                                       | 12. The beak conical, flattened at the sides, and the fore part of the head without feathers.                                                        |                                         | Screamer         | - Anhimus.       |
|         |                                                                                                                                                                       |                                                                                                                                                      |                                         | Gallinule        | - Porphyrio.     |
| XVIII.  | three genera                                                                                                                                                          | 1. The membranes of the toes simple, the beak strait and acute.                                                                                      |                                         | Water Hen        | - Gallinula.     |
|         |                                                                                                                                                                       | 2. The membranes of the toes jagged.                                                                                                                 |                                         | Phalarope        | - Phalaropus.    |
|         |                                                                                                                                                                       |                                                                                                                                                      |                                         | Coot             | - Fulica.        |
| XIX.    | one genus                                                                                                                                                             |                                                                                                                                                      |                                         | Grebe            | - Colymbus.      |
|         |                                                                                                                                                                       |                                                                                                                                                      |                                         | Guillemot        | - Uria.          |
| XX.     | three genera                                                                                                                                                          | 1. The beak strait and acute.                                                                                                                        |                                         | Puffin           | - Fratercula.    |
|         |                                                                                                                                                                       | 2. The beak flattened at the sides, with transverse striæ.                                                                                           |                                         | Auk              | - Alca.          |
|         |                                                                                                                                                                       |                                                                                                                                                      |                                         | Penguin          | - Spheniscus.    |
| XXI.    | three genera                                                                                                                                                          | 1. The beak strait, the extremity of the upper mandible bent.                                                                                        |                                         | Catarractes      | - Catarractes.   |
|         |                                                                                                                                                                       | 2. The beak strait and acute.                                                                                                                        |                                         | Diver            | - Mergus.        |
| XXII.   | one genus                                                                                                                                                             |                                                                                                                                                      |                                         | Albatross        | - Albatrus.      |
|         |                                                                                                                                                                       |                                                                                                                                                      |                                         | Shearwater       | - Puffinus.      |
|         |                                                                                                                                                                       |                                                                                                                                                      |                                         | Petrel           | - Procellaria.   |
| XXIII.  | six genera                                                                                                                                                            | 1. The beak bent near its point.                                                                                                                     |                                         | Arctic Bird      | - Stercorarius.  |
|         |                                                                                                                                                                       |                                                                                                                                                      |                                         | Gull             | - Larus.         |
|         |                                                                                                                                                                       |                                                                                                                                                      |                                         | Tern             | - Sterna.        |
|         |                                                                                                                                                                       |                                                                                                                                                      |                                         | Razorbill        | - Rygobopalia.   |
|         |                                                                                                                                                                       | 2. The beak flattened at the sides.                                                                                                                  |                                         | Merganser        | - Merganser.     |
| XXIV.   | three genera                                                                                                                                                          | 1. The beak rather cylindrical; the extremity of the upper mandible bent.                                                                            |                                         | Goose            | - Anser.         |
|         |                                                                                                                                                                       | 2. The beak convex on its upper part, and flat beneath.                                                                                              |                                         | Duck             | - Anas.          |
|         |                                                                                                                                                                       |                                                                                                                                                      |                                         | Darter           | - Anbinga.       |
|         |                                                                                                                                                                       |                                                                                                                                                      |                                         | Tropic Bird      | - Lepturus.      |
|         |                                                                                                                                                                       |                                                                                                                                                      |                                         | Booby            | - Sula.          |
|         |                                                                                                                                                                       |                                                                                                                                                      |                                         | Cormorant        | - Phalacrocorax. |
|         |                                                                                                                                                                       |                                                                                                                                                      |                                         | Pelican          | - Onocrocalus.   |
| XXV.    | five genera                                                                                                                                                           | 1. The beak acute.                                                                                                                                   |                                         | Flamingo         | - Phœnicopterus. |
|         |                                                                                                                                                                       |                                                                                                                                                      |                                         | Avocet           | - Avocetta.      |
|         |                                                                                                                                                                       |                                                                                                                                                      |                                         | Courier          | - Corrirea.      |
| XXVI.   | three genera                                                                                                                                                          | 2. The beak not indented.                                                                                                                            |                                         |                  |                  |



Table IV. *The Division of oviparous Quadrupeds, by DAUBENTON.*

CLASS I. The body covered with a shell. } Consisting of 15 species.  
TORTOISES.

Genus I. Lizards } Consisting of 8 species.  
which have the body  
somewhat tubercu-  
lated, and the tail  
flat.

Genus II. Lizards } Consisting of 12 species.  
which have the tail  
verticillated.

Genus III. Lizards } Consisting of 5 species.  
which have the tail  
round, scaly, and  
shorter than the  
body.

CLASS II. The body  
naked, with a tail.

Lizards.

Genus IV. Lizards } Consisting of 17 species.  
which have the tail  
round, scaly, and  
longer than the body.

OVIPAROUS  
QUADRUPEDS.

which have the tail  
round, scaly, and  
longer than the body

Consisting of 17 species.

Genus V. Lizards  
which have four  
toes on the fore  
feet, and the body  
smooth.

Consisting of 5 species.

Genus VI. Winged  
Lizards. } The Dragon.

Genus I. Toads;  
the body round  
and tuberculated,  
the legs short.

Consisting of 14 species.

Genus II. Frogs  
which have the body  
long.

Consisting of 11 species.

Genus III. Frogs  
which have the toes  
terminating in a  
broad flat surface.

Consisting of 9 species.

CLASS III. The body  
naked, without a tail.

Table V.

*The Division of Serpents by DAUBENTON.*

|                                                                                                                                           |                                    |
|-------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------|
| SERPENTS.                                                                                                                                 |                                    |
| Genus I. Rattle-snakes; or such as have a Rattle<br>at the extremity of the tail.<br>Crotalus, Linnæi.                                    | It consists of four species.       |
| Genus II. Serpents which have large scales (Scuta)<br>beneath the body and tail; without<br>a Rattle.<br>Boa, Linn.                       | It consists of ten species.        |
| Genus III. Serpents which have large scales (Scuta)<br>beneath the body, and small scales<br>(Squamæ) beneath the tail.<br>Coluber, Linn. | It consists of ninety-six species. |
| Genus IV. Serpents which have small scales beneath<br>the body and tail.<br>Anguis, Linn.                                                 | It consists of thirteen species.   |
| Genus V. Serpents which have the body divided<br>into annuli or rings.<br>Amphisbæna, Linn.                                               | It consists of two species.        |
| Genus VI. Serpents which have the skin naked<br>smooth.<br>Cæcilia, Linn.                                                                 | It consists of two species.        |



*The Ichthyologic System of* GOUAN.

|                                                                                                                                                            |     |                 |                      |
|------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|-----------------|----------------------|
| <p>Order I. Apodes.</p> <p>The ventral fins wanting.</p>                                                                                                   | 1.  | _____           | <i>Trichiurus.</i>   |
|                                                                                                                                                            | 2.  | Sword-fish -    | <i>Xiphias.</i>      |
|                                                                                                                                                            | 3.  | _____           | <i>Ophidium.</i>     |
| <p>Order II. Jugulares.</p> <p>The belly-fins placed beneath the neck.</p>                                                                                 | 1.  | Weveer -        | <i>Trachinus.</i>    |
|                                                                                                                                                            | 2.  | _____           | <i>Uranoscopus.</i>  |
|                                                                                                                                                            | 3.  | Dragonet -      | <i>Callyonymus.</i>  |
|                                                                                                                                                            | 4.  | Blenny -        | <i>Blennius.</i>     |
| <p>Class I. ACANTHOPTERYGII.</p> <p>The fins supported by small bones.</p> <p>Order III. Thoracici.</p> <p>The ventral fins placed beneath the breast.</p> | 1.  | Goby -          | <i>Gobius.</i>       |
|                                                                                                                                                            | 2.  | _____           | <i>Cepola.</i>       |
|                                                                                                                                                            | 3.  | Dolphin -       | <i>Coryphæna.</i>    |
|                                                                                                                                                            | 4.  | Mackrel -       | <i>Scomber.</i>      |
|                                                                                                                                                            | 5.  | Wrasse -        | <i>Labrus.</i>       |
|                                                                                                                                                            | 6.  | Gilthead -      | <i>Sparus.</i>       |
|                                                                                                                                                            | 7.  | _____           | <i>Chætodon.</i>     |
|                                                                                                                                                            | 8.  | _____           | <i>Sciæna.</i>       |
|                                                                                                                                                            | 9.  | Perch -         | <i>Perca.</i>        |
|                                                                                                                                                            | 10. | Father Lasher - | <i>Scorpena.</i>     |
|                                                                                                                                                            | 11. | Surmullet -     | <i>Mullus.</i>       |
|                                                                                                                                                            | 12. | Gurnard -       | <i>Trigla.</i>       |
|                                                                                                                                                            | 13. | Bull-head -     | <i>Cottus.</i>       |
|                                                                                                                                                            | 14. | Doree -         | <i>Zeus.</i>         |
|                                                                                                                                                            | 15. | _____           | <i>Trachipterus.</i> |
|                                                                                                                                                            | 16. | Stickle-back -  | <i>Gasterosteus.</i> |
| <p>Order IV. Abdominales.</p> <p>The ventral fins placed beneath the abdomen.</p>                                                                          | 1.  | Catfish -       | <i>Silurus.</i>      |
|                                                                                                                                                            | 2.  | Mullet -        | <i>Mugil.</i>        |
|                                                                                                                                                            | 3.  | _____           | <i>Polynemus.</i>    |
|                                                                                                                                                            | 4.  | _____           | <i>Theuys.</i>       |
|                                                                                                                                                            | 5.  | _____           | <i>Elops.</i>        |
| <p>The gills perfect,</p>                                                                                                                                  | 1.  | Eel -           | <i>Murena.</i>       |
|                                                                                                                                                            | 2.  | Gymnotus -      | <i>Gymnotus.</i>     |



# FISHES

have either

## Class II. MALACOPTERYGII.

The fins soft, and without bones.

## Class III. BRANCHIOSTEGI.

The gills imperfect.

- Order I. Apodes.

Order II. Jugulares.

Order III. Thoracici.

Order IV. Abdominales.
- Order I. Apodes.

Order II. Jugulares.

Order III. Thoracici.

Order IV. Abdominales.

1. Eel - - - - - *Muraena.*
2. Gymnotus - - - - - *Gymnotus.*
3. Wolf-fish - - - - - *Ana. bicbas.*
4.            - - - - - *Stromateus.*
5. Launce - - - - - *Ammodytes.*

1.            - - - - - *Lepadogaster.*
2. Cod - - - - - *Gadus.*

1. Flounder - - - - - *Pleuronectes.*
2. Sucking-fish - - - - - *Echeneis.*
3.            - - - - - *Lepidopus.*

1.            - - - - - *Loricaria.*
2. Atherine - - - - - *Atherina.*
3. Salmon - - - - - *Salmo.*
4.            - - - - - *Fisularia.*
5. Pike - - - - - *Esox.*
6. Argentine - - - - - *Argentina.*
7. Herring - - - - - *Clupea.*
8. Flying fish - - - - - *Exocetus.*
9. Carp - - - - - *Cyprinus.*
10. Loche - - - - - *Cobitis.*
11.            - - - - - *Amia.*
12.            - - - - - *Mormyrus.*

1. Pipe-fish - - - - - *Syngnathus.*
2. Balistes - - - - - *Balistes.*
3.            - - - - - *Ostracion.*
4.            - - - - - *Tetraodon.*
5. Sun-fish - - - - - *Diodon.*

- 1 Angler - - - - - *Lopbius.*
1. Lump-fish - - - - - *Cyclopterus.*

1.            - - - - - *Centriscus.*
2.            - - - - - *Pegasus.*

Table VII.

| SECTIONS.                                                                                       | ARTICLES.                                                                                               | ORDERS.                                                                                                                  |
|-------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|
| <p>Sect. I.<br/>Coleoptera, or<br/>Insects with crustaceous shells over their wings . . . .</p> | <p>I. . . . . Either the shell is hard, and covers the whole abdomen, and their feet have . . . . .</p> | <p>I. . . . . Either five articulations to all the feet, such as the</p>                                                 |
|                                                                                                 |                                                                                                         | <p>II. . . . . Or, four articulations to all the feet, such as the</p>                                                   |
|                                                                                                 |                                                                                                         | <p>III. . . . Or, three articulations to all the feet, such as . .</p>                                                   |
|                                                                                                 |                                                                                                         | <p>IV. . . . Or, five articulations in the two first pair of feet, and four only in the hinder pair, such as . . . .</p> |
|                                                                                                 |                                                                                                         | <p>I. . . . . Either five articulations to all the feet . . . . .</p>                                                    |
|                                                                                                 |                                                                                                         | <p>II. . . . . Or four articulations to all the feet . . . . .</p>                                                       |
|                                                                                                 |                                                                                                         | <p>III. . . . Or three articulations to all the feet . . . . .</p>                                                       |
|                                                                                                 |                                                                                                         | <p>IV. . . . Or five articulations to the two first pair of feet, and four to the latter . . . . .</p>                   |
|                                                                                                 |                                                                                                         | <p>I. . . . . Either five articulations to the two first pair of feet, and four only to the latter . . . . .</p>         |
|                                                                                                 |                                                                                                         | <p>II. . . . . Or two articulations to all the feet . . . . .</p>                                                        |
|                                                                                                 |                                                                                                         | <p>III. . . . Or three articulations to all the feet . . . . .</p>                                                       |
|                                                                                                 |                                                                                                         | <p>IV. . . . Or four articulations to all the feet . . . . .</p>                                                         |
|                                                                                                 |                                                                                                         | <p>V. . . . Or five articulations to all the feet . . . . .</p>                                                          |
|                                                                                                 | <p>III. . . . The shell is soft, and their feet have . . . . .</p>                                      | <p>I. . . . . Either five articulations to all the feet . . . . .</p>                                                    |
|                                                                                                 |                                                                                                         | <p>II. . . . . Or four articulations to all the feet . . . . .</p>                                                       |
|                                                                                                 |                                                                                                         | <p>III. . . . Or three articulations to all the feet . . . . .</p>                                                       |
|                                                                                                 |                                                                                                         | <p>IV. . . . Or four articulations to all the feet . . . . .</p>                                                         |
|                                                                                                 |                                                                                                         | <p>V. . . . Or five articulations to all the feet . . . . .</p>                                                          |

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| GENERA.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | SECTIONS.                                                                                                                                                                                                                                                                                                                                                               | ARTICLES.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | GENERA. |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|
| <div>Platycerus.</div> <div>Ptilinus.</div> <div>Scarabæus.</div> <div>Copris.</div> <div>Attelabus.</div> <div>Dermestes.</div> <div>Byrrhus.</div> <div>Anthrenus.</div> <div>Cistela.</div> <div>Pectis.</div> <div>Cucujus.</div> <div>Elater.</div> <div>Buprestis.</div> <div>Bruchus.</div> <div>Lampyrus.</div> <div>Cicindela.</div> <div>Omalijus.</div> <div>Hydrophylus.</div> <div>Dyticus.</div> <div>Gyrinus.</div> <div>Melolontha.</div> <div>Prionus.</div> <div>Cerambyx.</div> <div>Leptura.</div> <div>Stenocoelus.</div> <div>Luperus.</div> <div>Cryptocephalus.</div> <div>Crioceris.</div> <div>Altica.</div> <div>Galeruca.</div> <div>Chrysomela.</div> <div>Meloboris.</div> <div>Rhinomacer.</div> <div>Curculio.</div> <div>Bostrychus.</div> <div>Clerus.</div> <div>Anthribus.</div> <div>Scolytus.</div> <div>Cassida.</div> <div>Anaspis.</div> <div>Coccinella.</div> <div>Tritoma.</div> <div>Diaperis.</div> <div>Pyrochroa.</div> <div>Cantharis.</div> <div>Tenebrio.</div> <div>Mordella.</div> <div>Notoxus.</div> <div>Cerocoma.</div> <div>Staphylinus.</div> <div>Necydalis.</div> <div>Forficula.</div> <div>Meloe.</div> <div>Blatta.</div> <div>Trips.</div> <div>Gryllus.</div> <div>Acrydium.</div> <div>Locusta.</div> <div>Mantes.</div> | <div>II. . . . Hemiptera, or insects whose upper wings are half crustaceous, half membranaceous. . . . .</div> <div>III. . . . Insects with four farinaceous wings . . . . .</div> <div>IV. . . . Insects with four naked membranaceous wings . . . . .</div> <div>V. . . . Insects with two wings . . . . .</div> <div>VI. . . . Insects without wings . . . . .</div> | <div>Cicada.</div> <div>Cimex.</div> <div>Naucoris.</div> <div>Notonecta.</div> <div>Corixa.</div> <div>Hepa.</div> <div>Ptylla.</div> <div>Aphis.</div> <div>Cermes.</div> <div>Coccus.</div> <div>Papilio.</div> <div>Sphinx.</div> <div>Pterophorus.</div> <div>Phalæna.</div> <div>Tinea.</div> <div>I. . . . Three articulations to the feet .</div> <div>II. . . . Four articulations to the feet .</div> <div>III. . . . Five articulations to the feet</div> <div>Libellula.</div> <div>Perla.</div> <div>Raphidia.</div> <div>Ephemera.</div> <div>Phryganea.</div> <div>Hemerobius.</div> <div>Formica.</div> <div>Panorpa.</div> <div>Crabro.</div> <div>Urocerus.</div> <div>Tenthredo.</div> <div>Cynips.</div> <div>Diplolepis.</div> <div>Eulophus.</div> <div>Ichneumon.</div> <div>Vespa.</div> <div>Apis.</div> <div>Formica.</div> <div>Oestrus.</div> <div>Tabanus.</div> <div>Asilus.</div> <div>Stratiomys.</div> <div>Musca.</div> <div>Stomoxys.</div> <div>Volucella.</div> <div>Nemotelus.</div> <div>Scatopse.</div> <div>Hypoboscæ.</div> <div>Tipula.</div> <div>Bibio.</div> <div>Culex.</div> <div>Pediculus.</div> <div>Podura.</div> <div>Forbicina.</div> <div>Pulex.</div> <div>Chelifer.)</div> <div>Acarus.</div> <div>Phalangium.</div> <div>Aranea.</div> <div>Monoculus.</div> <div>Binoculus.</div> <div>Cancer.</div> <div>Oniscus.</div> <div>Asellus.</div> <div>Scolopendra.</div> <div>Iulus.</div> |         |

GENUS.

1. Gordius.
2. Lumbricus.
3. Ascarides.
4. Sanguisuga.
5. Limax.
6. Tania.

Section I.

Naked worms

-----

1. Patella.
2. Haliotis.
3. Tubulus.
4. Nautilus.
5. Cochlea.
6. Nerites.
7. Trochus.
8. Cilindrus.
9. Voluta.
10. Strombis.
11. Buccinum.
12. Murex.
13. Purpura.
14. Porcellana.
15. Globus.

Order I. With univalve shells.

WORMS

Section II.

1. Ostrea.
2. Chama.
3. Concha cordis.



# WORMS

## ARE

### Section II.

Covered worms.

Order II. With bivalve shells.

1. Ostrea.
2. Chama.
3. Concha cordis.
4. Pecten.
5. Mytilus.
6. Solen.

Order III. With polyvalve shells.

1. Pholas.
2. Balanus.
3. Concha Anatifera.
4. Chiton.

### Section III.

Crustaceous worms. — — — — —

1. Aferias.
2. Echinus.

Order I. Naked polypi.

1. Hydra.
2. Urtica Marina.

Order II. Polypi, in corneous or ligneous cells.

1. Lithophyton.
2. Corallina.

### Section IV. Polypi,

Order III. Polypi in cretaceous cells.

1. Corallium.
2. Madrepora.

Order IV. Polypi in soft and spongy cells.

1. Eschara.
2. Spongia.
3. Alcyonium.